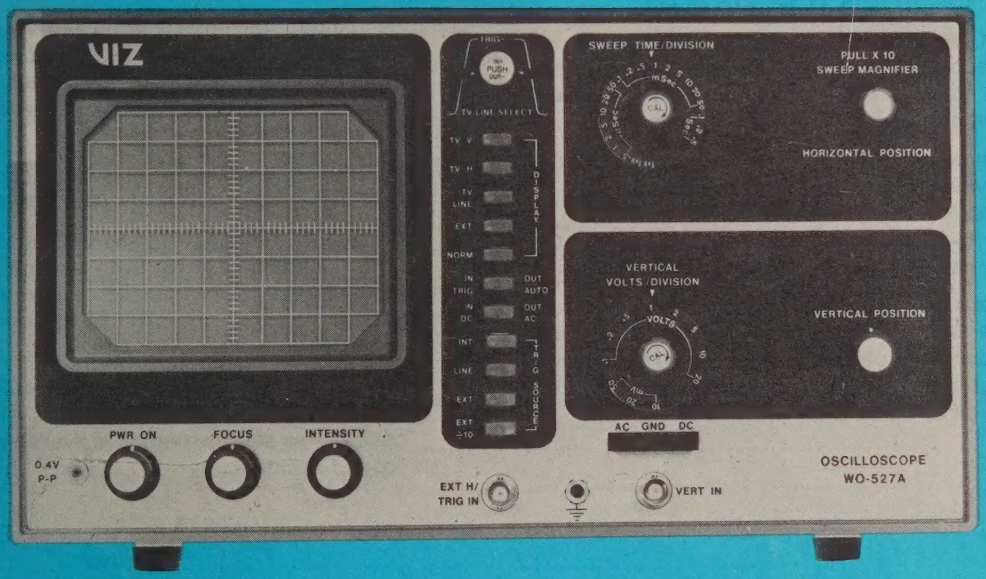
VIZ Test Instruments

WO-527A Instruction Manual



15 MHZ

Solid State

Triggered

Oscilloscope

VIZ Mfg. Co. 335 E. Price St. Phila., Pa. 19144

Price $3.50

SAFETY PRECAUTIONS

This instrument is equipped with a three-wire power cord which connects the metal case and ground lead to the powerline ground. To prevent lethal shocks or equipment damage when servicing equipment with a three-wire power cord, ALWAYS ELECTRICALLY ISOLATE SUCH EQUIPMENT WITH AN ISOLATION TRANSFORMER, such as WP-25A, WP-26A, or WP-27A Isotap.*

Care should be exercised to avoid striking the cathode-ray tube or subjecting it to more than moderate pressure in handling. Because the tube contains a high vacuum, implosion might result in injury from flying glass.

Always become more familiar with the equipment under test before working on it, bearing in mind that high voltages may appear at unexpected points in defective equipment. Additional precautions which experience in the industry has shown to be important are listed below:

1. It is good practice to remove power before connecting test leads to high-voltage points. If this is impractical, be especially careful to avoid accidental contact with equipment racks and other objects which can provide a ground. Working with one hand in your pocket and standing on a properly insulated floor lessens the danger of shock.
2. Filter capacitors may store a charge large enough to be hazardous. Therefore, discharge filter capacitors before attaching test leads.
3. Remember that leads with broken insulation provide the additional hazard of high voltages appearing at exposed points along the leads. Check test leads for frayed or broken insulation before working with them.
4. To lessen the danger of accidental shock, disconnect test leads immediately after test is completed.
5. Remember that the risk of severe shock is only one of the possible hazards. Even a minor shock can place the operator in hazard of more serious risks such as a bad fall or contact with a source of higher voltage.
6. The experienced operator continuously guards against injury and does not work on hazardous circuits unless another person is available to assist in case of accident.

PATENT STATEMENT

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FOREWORD

The cathode-ray oscilloscope is probably the single most useful tool used for electronic maintenance and research. It affords a visual display of many kinds of electrical phenomena, including voltage and current amplitudes, waveforms and phase relationships. In fact, it opens doors for the determination of component and equipment behavior under virtually all conditions of operation. Perhaps nothing else has been as informative to those who seek information in the world of electronics as the cathode-ray oscilloscope, more popularly identified by the single word "scope".

Familiarity with the use of the oscilloscope is a distinct advantage to every technician, engineer, and student engaged in electronics. There is nothing complex about the operation of the oscilloscope. If anything is complex, it is the interpretation of what appears on its screen. In this respect, it is hoped that the contents of this Instruction Book will be of assistance.

No attempt is made to cover every phase of oscilloscope application. Only those details which relate to field repair and manufacturing applications of maintenance and production of electronic equipment have been included. In addition, a special effort has been made to plan the contents of this book to serve the many schools of instruction where electronics is taught.

Human engineering, the science of inter-relation between man and science, has been employed in the design of the WO-527A to give you an instrument that is easy and efficient to use, convenient to carry around, and quickly repairable.

Extensive metrology testing combined with the latest technology, such as cold switching and component derating has resulted in an instrument with superior reliability.

Triggering has been designed to be easy to accomplish and as stable as possible, since the trigger control is the most useful knob on an oscilloscope. Circuitry that ensures drift-free signals, optimum amplitude of trigger pick-offs, and the availability of bandwidth selection for trigger signals provides VIZ oscilloscopes with a stable display over the greatest possible signal conditions.

Human engineering, up-to-date technology, functional facility, serviceability and reliability are all important parts of design. When treated with the importance that each deserves, the results reach into virtually all aspects of the instruments, the specifications, performance, usability and even appearance. Of course, this does not stop with oscilloscopes, but applies to all the instruments found in the VIZ Test Instruments Line.

DESCRIPTION

The VIZ WO-527A is a high performance DC to 15 MHz Triggered sweep oscilloscope designed with advanced-technology, solid-state IC circuitry with a 5-inch (8 x 10 cm) viewing screen. Though popularly priced, this remarkable oscilloscope provides the features and functions required for general purpose, production and servicing applications, and is also ideally suited for many industrial, educational, and scientific research laboratory applications.

Frequency response of the vertical amplifier extends beyond 15MHz. The triggered sweep system provides calibrated time base settings from 0.5 microseconds/cm to 0.5 seconds/cm. Sweep speeds up to 50 nanoseconds can be obtained by using the times ten sweep magnifier function for trace expansion; an LED is illuminated when the "X10" sweep magnifier is in use. In addition, preset TV Vertical and TV Horizontal sweep frequencies are included for stable automatic lock-in of television video waveforms. A special TV LINE SELECT function permits the display of a single line from a TV video frame—a valuable aid in servicing TV receivers of all kinds, as well as broadcast transmission monitoring and video tape recorders. Continuous adjustment of sweep speed between calibrated positions is also provided.

A unique trigger level adjustment control utilizes LED indicators. Pushing in or out on the trigger control selects trigger polarity and illuminates one of the two red LEDS which show at a glance either positive or negative polarity. Rotating this control triggers the sweep and a green LED is illuminated. When either of the red polarity LEDS and the green TRIG LED is on, centering the Vertical and Horizontal position of the trace will bring the sweep in to full view eliminating the need for beam finders, etc.

Convenient front panel pushbutton switches allow fast, easy selection of oscilloscope display mode and sweep functions. An internal 0.4 volt peak-to-peak square wave calibrating signal is provided through a front panel jack for convenient voltage measurement and probe compensation adjustment. Other features include AC or DC coupling for the vertical amplifier, AC, DC, or ground reference for the input signal, selection of adjustable or automatic trigger mode, and "divide by ten" trigger source function to insure stable trace lock-in. The bandwidth of the horizontal amplifier extends from DC to 1 MHz.

At the rear of the WO-527A, located inside the AC line cord storage compartment, is the input voltage selection switch permitting operation of either 115V AC or 230V AC 50/60Hz, and an easily replaceable fuse in its holder. Also located here is an RCA type Phono jack for "Z" axis modulation.

Make sure the slide switch is in the proper position (115V or 230V AC) before applying power to the instrument.

Both low voltage and high voltage power supplies are fully regulated preventing trace bounce and blooming due to line voltage fluctuations. Other features include a flat-face cathode-ray tube with a P-31 phosphor, full mu-metal shielding, and a special graticule producing a clear, sharp, blue-white trace.

The WO-527A Oscilloscope is equipped with a tilt stand adjustable handle, and comes equipped with VIZ's new WG-478 hook-on probe.

SPECIFICATIONS

FREQUENCY RESPONSE (usable to 27 MHz)

"Y" Axis-Vertical Amplifier
- DC Function ..... DC to 15 MHz (−3dB)
- AC Function ..... 20 Hz to 15 MHz (−3dB)
- Rise Time (Vertical) 23ns

"X" Axis-Horizontal Amplifier
- AC Function ..... 50Hz to 1 MHz (−3dB)

SENSITIVITY

Vertical Amplifier ..... 10mV P-P/cm
Horizontal Amplifier ..... 100mV P-P/cm
"Z" Axis Typical ..... 5V P-P to cutoff

VOLTAGE MEASUREMENTS

Vertical ..... 66± 1dB, 11 steps
Horizontal ..... 40± 2dB, 3 steps
Calibration Test Jack ..... 0.4V P-P ± 1%
Max. Input, Vertical Amp ..... 600V P-P
Max. Input, Horizontal Amp ..... 600V P-P

INPUT IMPEDANCE

Vertical Amplifier ..... 1 Meg. ohm shunted by 28 pf
With XI Probe ..... 1 Meg. ohm shunted by 56 pf
With X10 Probe ..... 10 Meg ohm shunted by 6.5 pf
Horizontal Amplifier ..... 1 Meg. ohm shunted by 30 pf

TRIGGER FUNCTIONS

Trigger Input ..... 1 Meg. ohm shunted by 30 pf
Trigger Modes ..... Internal pos.
Internal neg.
External
External ÷ 10
TV V lo pass
TV H hi pass
TV line
60 Hz
Trigger Sensitivity ..... 10mv, DC to 15 MHz
Trigger Stability ..... 10mv + or −
Trigger Adjustment Range ..... 20% to 80% P-P
Trigger Display, + or − ..... LED

DISPLAY ..... 8 x 10cm. Graticule calibrated to 0.2cm

SWEEP OSCILLATOR

Time ..... 0.5μ sec/cm to 0.5 sec/cm in 19 steps, accurate to ± 1%

Expandable to X10

POWER REQUIREMENTS

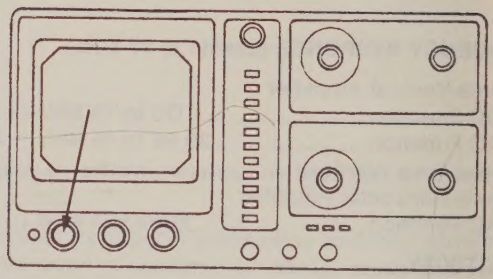
Frequency ..... 50-60 Hz
Voltage Std 108-130V
Voltage (Int. Switch) 215-250V
Power Consumption ..... Approx. 50 watts

MECHANICAL DIMENSIONS

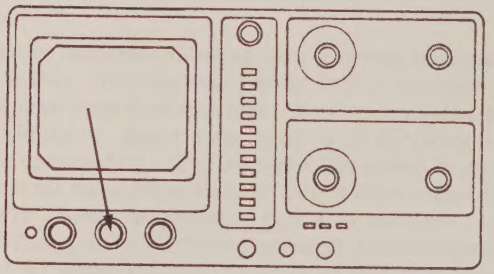
Height ..... 7.5″ (19.1cm)
Width ..... 13.5″ (34.3cm)
Length ..... 17.5″ (44.5cm)
Weight ..... 21 lbs. (9.5Kg.)

Note: Performance Figures Are For A Line Voltage Of 120 Volts, 60Hz, at 23°C.

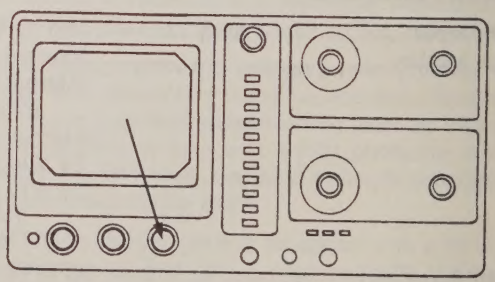
FUNCTION OF CONTROLS & TERMINALS



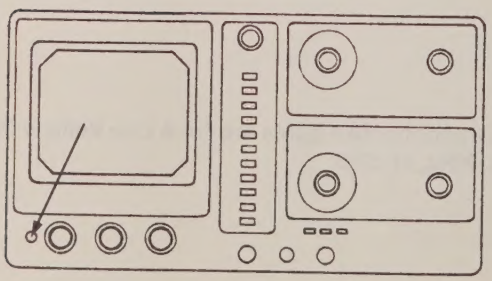
"PWR ON"
Turn clockwise past mechanical detent, (balance of the control has no function).



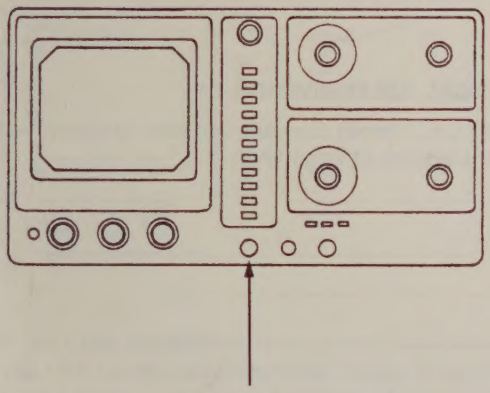
"FOCUS"
Controls sharpness of the trace.
May require adjustment when the INTENSITY control setting is changed.



"INTENSITY"
Varies beam brightness



"0.4 V P-P,"
A precision square wave source 1KHz, 0.4V peak to peak, for calibration purposes.



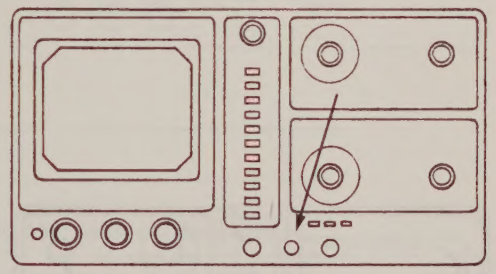
"EXT H/TRIG IN"
BNC Connector for connecting external signal to the horizontal deflection amplifier directly, or the sweep triggering circuits.

For the horizontal amplifier, use the following push button controls:

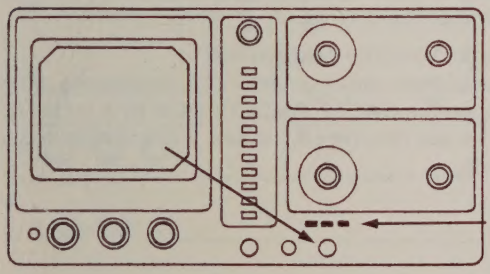
1) DISPLAY "EXT"
2) TRIG SOURCE "EXT" OR "EXT ÷ 10"
3) "IN DC" for direct coupling or "OUT AC" to isolate input circuits from DC voltage levels.
4) Use CAL (small center knob of the SWEEP TIME/DIVISION Control) as a gain control.

For external triggering of sweep circuits use the following push button controls.

1) DISPLAY group: "TV V", "TV H", "TV LINE" or "NORM".
2) TRIG SOURCE "EXT" or "EXT ÷ 10"

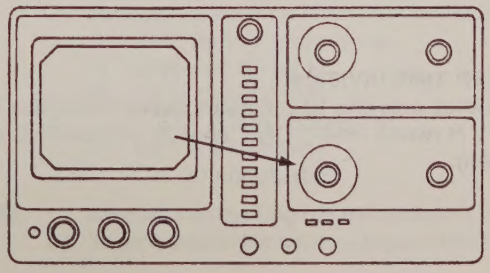


"GROUND JACK"
For external grounding of scope case and shielding

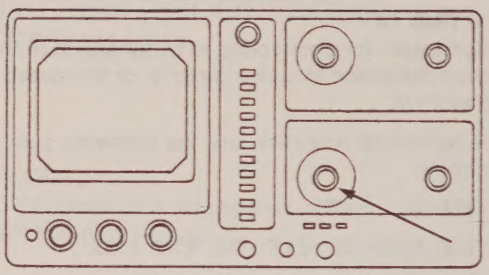


"VERTICAL INPUT"
BNC CONNECTOR for WG-478 probe and cable. Use one of the following push button controls:

1) "DC" for direct coupling into vertical amplifier.
2) "AC" input signal coupled by a capacitor.
3) "GND" grounds input of vertical amplifier, but input signal to BNC is not grounded.



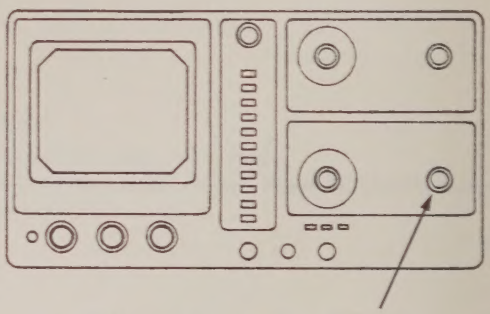
"VERTICAL VOLTS/DIVISION"
Large knob provides 11 (eleven) calibrated input ranges from 10 millivolts/cm to 20 volts/cm. Small CAL knob must be in full CW position.

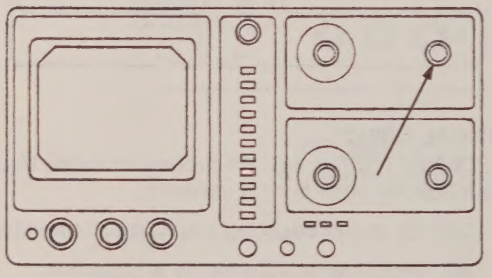


"VERTICAL VOLTS/DIVISION CAL"

(Small "CAL" knob) provides variation of input level between positions of large knob.

"VERTICAL POSITION"
Control knob adjusts vertical position of display.





"HORIZONTAL POSITION"
Large knob is coarse adjustment of horizontal position of the display.

Rotation of small knob is the fine horizontal position adjustment of the display.

"PULL X10 SWEEP MAGNIFIER"
The small knob when pulled out multiplies the indicated values on the SWEEP TIME/DIVISION by a factor of 10. Thus 1m sec becomes 0.1 m sec. 2 m sec becomes 0.2 m sec., etc,

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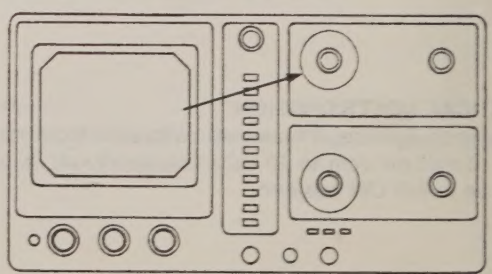
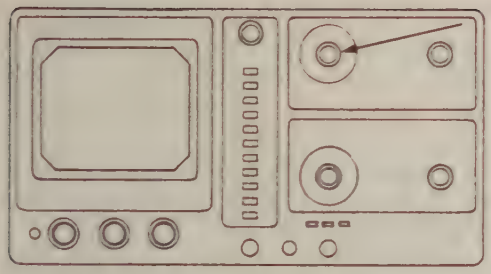
"SWEEP TIME/DIVISION"
Large knob provides 19 calibrated sweep times plus TV V and TV H (when small "CAL" knob is in maximum cw position).



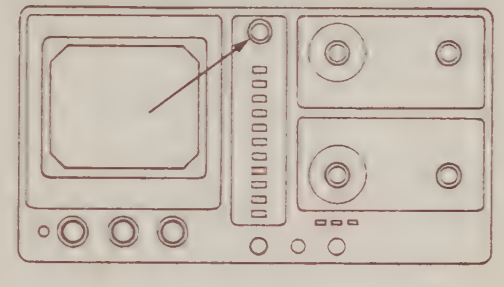


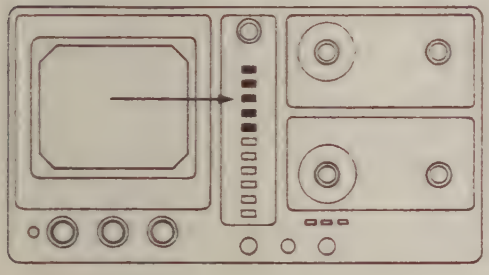
"SWEEP TIME/DIVISION"—CAL (small knob)

1) Continuous control of sweep times for any position of large knob.
2) Gain control for horizontal amplifier (see EXT H/TRIG IN section)

"TRIG - TV LINE SELECT"

1) The RED LEDS indicate whether sweep is triggered from a positive or negative portion of any ongoing signal.
2) Rotation of the knob determines the signal level at which triggering takes place.
   Positive or *negative* trigger polarity is selected by pushing in then releasing the knob. The Green LED above the knob, when lighted, indicates the presence of triggering.
3) When the DISPLAY button "TV LINE" is pressed and the TRIG/TV LINE SELECT knob is rotated, the display on the CRT will move left or right. When viewing composite video, this will permit examining each line of information separately.





"DISPLAY" (Mutually exclusive set)

"TV V" Allows the full composite video waveform to be displayed. However, only vertical sync pulses trigger the sweep.

"TV H" Allows the full composite video wave form to be displayed. However, only horizontal sync pulses trigger the sweep.

"TV LINE" Allows the full composite video waveform to be displayed, and permits each line of video information to be observed separately if desired. The Sweep is triggered by vertical sync pulses.

"EXT" Disables sweep and trigger circuits and connects horizontal amplifiers to the TRIG SOURCE buttons permitting:

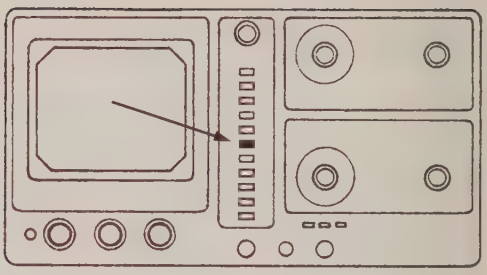
1) LINE—60 Hz input
2) EXT—direct access to EXT H BNC Connector
3) EXT ÷ 10—inserts ÷ 10 attentuator

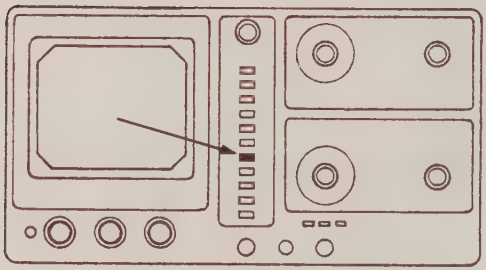
"NORM" Normal Sweep. Use combinations of 6 lower buttons for various trigger modes.

"IN TRIG/OUT AUTO"

"IN TRIG" Trigger signal is required for sweep.

"OUT AUTO" Sweep will continue in the absence of a trigger signal.





"IN DC/OUT AC"

"IN DC" Provides DC coupling of the TRIG SOURCE to the trigger amplifier.

"OUT AC" Provides AC coupling of the TRIG SOURCE to the amplifier.

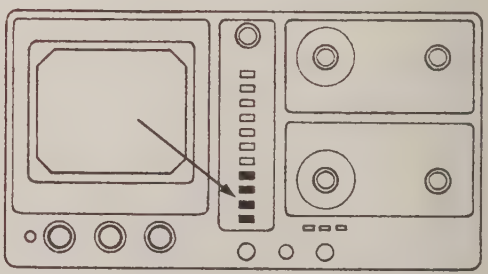
"TRIG SOURCE" (mutually exclusive set)

"INT" Vertical amplifier

"LINE" Line frequency

"EXT" EXT H/TRIG IN BNC

"EXT ÷ 10" EXT H/TRIG IN BNC thru ÷ 10 attenuator.



OPERATION:

In order to become familiar with the operation of the WO-527A, proceed as follows:

a) IMPORTANT: Be sure that the PWR ON switch is in the full counterclockwise off position and the input line voltage selector switch in rear compartment is set for the proper line voltage. Improper setting could result in a blown fuse, or additional damage due to high current pulses.

b) Plug line cord into appropriate grounded outlet.

c) Connect Universal Probe WG-478A to VERT IN Connector and insert the probe end into the 0.4V P-P calibration jack. Set controls as follows:

1) PWR ON—clockwise until detent is noted.
2) FOCUS—center of rotation
3) INTENSITY—Clockwise approximately ¾ turn
4) TRIG TV LINE SELECT—any position
5) DISPLAY—"NORM"
6) IN TRIG/OUT AUTO—out
7) IN DC/OUT AC—out
8) TRIG SOURCE—"INT"
9) SWEEP TIME/DIVISION—"0.5 m sec."
10) SWEEP TIME/DIVISION CAL KNOB—CW
11) HORIZONTAL POSITION—center of rotation
12) SWEEP MAGNIFIER—in—(LED will be off)
13) VERTICAL VOLTS/DIVISION—".1 volt"
14) VERTICAL POSITION—center of rotation
15) GND—in

d) 1) If there is no display on the screen, check that the INTENSITY control is advanced clockwise, approximately ¾ turn, then rotate VERTICAL POSITION control until the display is visible. Center this using the VERTICAL POSITION and HORIZONTAL POSITION control.

2) Push in AC. There will now be two horizontal lines 4 cm apart or a square wave whose upper and lower excursions are 4 cm. apart.

3) If the two horizontal lines are present, adjust the TRIG Knob either CW or CCW until the pattern locks in. Note that the green TRIG LED is now on, in addition to one of the two red LEDs.

4) Push in and release the TRIG knob. Note that one red LED will go out and the other red LED will go on. When knob is IN, triggering will be on the positive slope. When knob is OUT, triggering will be on the negative slope of the incoming signal. The LEDs indicate which trigger slope is in use.

5) Push the IN DC/OUT AC button in. Note that when the display is moved up and down using the VERTICAL POSITION knob, the display will move in and out of the trigger zone, producing a running display when out of the trigger zone and a locked-in display when in the trigger zone. Loss of triggering is indicated by the green LED going OFF. The display may be again triggered by rotation of the TRIG knob. The IN DC/OUT AC push button control applies to all four TRIG SOURCE positions.

6) Push the IN TRIG/OUT AUTO button in. Note that when the pattern is moved by the VERTICAL POSITION knob, the display will disappear and the green LED will go out when the display is moved either up or down out of the trigger area. Two dots, 4 cm apart, may be visible at the right of the screen indicating the circuits are waiting to be triggered.
The IN TRIG/OUT AUTO button applies to the five push buttons below it.

Either IN TRIG sweep or OUT AUTO sweep may be used to lock in most waveforms. For most general purpose applications the OUT AUTO sweep will lock displays a little faster and easier. Short time pulses during long time periods are examples of phenomena that can only be seen by using TRIG sweep. Another example is the television VITS (Vertical Interval Test Signal). This signal occurs only during the vertical interval of the televised video waveform. "IN TRIG" sweep will easily lock-in the total VITS signal. See section of this manual on Applications for a more detailed explanation.

7) Rotate the SWEEP TIME/DIVISION CAL (small knob) CCW and note the display contracts toward the left indicating the sweep time/cm is increasing. Return clockwise to "CAL" position.

8) Z-Axis—The intensity modulation connector (RCA Phono Jack) is located in the line cord compartment. To illustrate Z-Axis modulation, connect VIZ WA 504B/44D Audio Generator #1 to the VERT IN jack. Set audio generator controls as follows:

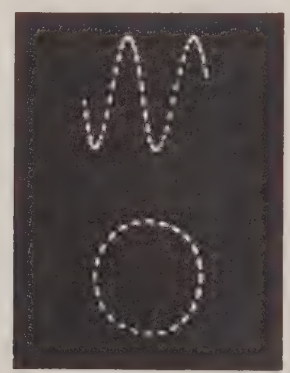
FREQUENCY—approx. 60 Hz
SINEWAVE
LEVEL—approx. ½ scale
OUTPUT—1 volt
WO-527A controls as follows:
DISPLAY—"EXT"

TRIG SOURCE (Line Frequency)—"LINE"
VERTICAL VOLTS/DIVISION—".1 volt"
VERT IN—"AC"

Adjust main frequency dial of Audio Generator #1, until a circle is obtained. Now connect Audio Generator #2 to the Z-Axis input connector (line compartment) and set this frequency to approximately 600 Hz—turn both LEVEL and OUTPUT controls maximum cw, WAVE-square. Note that the circle will be broken up into approximately 10 segments, rotating CW if the frequency of Audio Generator #2 is slightly less than 600 Hz and CCW if the frequency is slightly more than 600 Hz. The display segments may be made to stand still when the frequency of Audio Generator #2 is precisely 10 times that of the line frequency, here assumed to be 60 Hz. As the frequency of Audio Generator #2 is changed, different numbers of line segments may be made to stand still. The frequency of Audio Generator #2 will be the number of line segments times 60 Hz (line frequency) when the line segments are standing still. (See Figure 1-2)

Now turn down the level of Audio Generator #2. On the WO-527A push DISPLAY to "NORM" and TRIG SOURCE to "INT".

Set the frequency of the Audio Generator to 500Hz. Note that approximately 5 sine waves appear on the display. Set the frequency of Audio Generator #1 to approximately 10K Hz and advance LEVEL of Audio Generator #2 to maximum. Careful adjustment of the main frequency dial will cause the line segments to remain stationary. The frequency of Audio Generator #1, times the number of line segments, is equal to the frequency of Audio Generator #2. Note that the sweep retrace line is also modulated by the Z-Axis input frequency. (See Figure 1-1)



Oscilloscope traces showing Z-axis modulation.

Figure 1

In Figure 1-2 the Vertical and Horizontal frequencies are equal and 90° out of phase. The Z-Axis input frequency is 24 times the Vertical and Horizontal frequency.

TIME/CM-TO-FREQUENCY CORRELATION

Eleven vertical and nine horizontal lines on the graticule, spaced 1 centimeter apart, permit the measurement of displayed waveforms. The short markers on the centerlines are spaced 2 millimeters apart. Use the following formula or the Chart to determine the frequency of a waveform displayed on the CRT.

$$\text{SWEEP TIME/DIVISION}^{*} \text{ setting in seconds per cm.} \times \frac{1}{\text{MAGNIFIER}} \times \text{Centimeters for 1 cycle of unknown frequency} = \text{Period of unknown frequency} \quad \text{and,} \quad \frac{1}{\text{Period}} = \text{Frequency}$$

EXAMPLE: If one cycle of a waveform measures 2 cm on the graticule, with the TIME/CM switch at 1 ms and the X10 switch pulled out, then—

$.001^{**} \times \frac{1}{10} \times 2 = .0002$, and $\frac{1}{.0002} = 5{,}000$ Hz.

NOTES:

*CAL Knob Fully clockwise

**1 ms (millisecond) = 0.001 second

1 μs (microsecond) = 0.000001 second

1 ns (nanosecond) = 0.000000001 second

When the X10 switch is pulled out, the sweep travels 10 times faster, which makes the sweep *time* shorter by a factor of 10.

TIME/CM-TO-FREQUENCY CORRELATION CHART

SWEEP TIME/ DIVISION control	TIME PER 1 CM		FREQUENCY TIME BASE GENERATOR
	X10 SWEEP MAGNIFIER knob IN	OUT	
TV V	3.3 m sec	0.33 m sec	30 Hz
TV H	12.7 μ sec	1.27 μ sec	7850 Hz
0.5 μ sec	0.5 μ sec	0.05 μ sec	200,000 Hz
1 μ sec	1 μ sec	0.1 μ sec	100,000 Hz
2 μ sec	2 μ sec	0.2 μ sec	50,000 Hz
5 μ sec	5 μ sec	0.5 μ sec	20,000 Hz
10 μ sec	10 μ sec	1 μ sec	10,000 Hz
20 μ sec	20 μ sec	2 μ sec	5,000 Hz
50 μ sec	50 μ sec	5 μ sec	2,000 Hz
0.1 m sec	0.1 m sec	10 μ sec	1,000 Hz
0.2 m sec	0.2 m sec	20 μ sec	500 Hz
0.5 m sec	0.5 m sec	50 μ sec	200 Hz
1 m sec	1 m sec	0.1 m sec	100 Hz
2 m sec	2 m sec	0.2 m sec	50 Hz
5 m sec	5 m sec	0.5 m sec	20 Hz
10 m sec	10 m sec	1 m sec	10 Hz
20 m sec	20 m sec	2 m sec	5 Hz
50 m sec	50 m sec	5 m sec	2 Hz
0.1 sec	0.1 sec	10 m sec	1 Hz
0.2 sec	0.2 sec	20 m sec	0.5 Hz
0.5 sec	0.5 sec	50 m sec	0.2 Hz

APPLICATIONS

Before using your WO-527A be sure you thoroughly familiarize yourself with the functions of the Controls and Switches and the proper way to use them, as described on pages 8 through 12. In order to obtain a proper and meaningful display of various input wave forms, it is especially important that you use a correct probe, such as the VIZ WG-478-Universal Probe.

TV SERVICING

The use of an oscilloscope is extremely helpful in properly servicing television receivers. The oscilloscope can be used for viewing and measuring peak to peak AC voltages, establishing DC voltage levels, signal tracing, RF, IF, video and audio alignment work, color TV vector analysis, and in the latest TV receivers, viewing and measuring digital pulses.

While performing overall waveform analysis, you should take into consideration the wave shape as well as making amplitude and time measurements. Publications such as "SAMS Photofacts," "Tab Books," or Manufacturer's Technical Manuals, show key measured waveforms that will be noted on the schematic, or a reference will guide you to a waveform chart. Compare the observed waveform in question with the correct one shown in the schematic. Amplitude and time measurement are also important factors. Other considerations of equal importance are stabilization, missing or unwanted information.

Signals can be traced through various sections of a TV receiver to determine how circuits are functioning by noting the waveform information projected. When observing waveforms in the video amplifier and chromo circuits, it is essential that you use the X10 L0-Cap Universal Probe configuration of the VIZ WG-478 in order to minimize loading effects on the signal at the point of measurement.

When the scope is calibrated as described under OPERATION, the amplitude and time interval can be accurately measured.
NOTE: When the VIZ WG-478 Universal Probe is being used in the X10 Lo-Cap configuration, voltage readings must be multiplied by ten.

ANALYZING COMPOSITE VIDEO TELEVISION WAVEFORMS

Probably the most important waveform encountered in television service work is the composite video waveform.

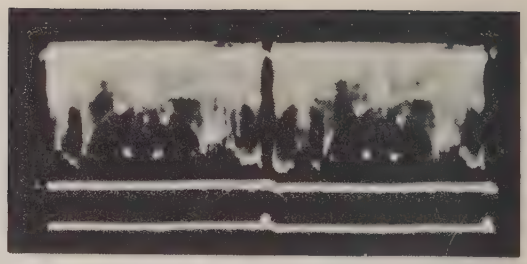


Figure 2
Composite TV waveform showing video information, vertical blanking interval, and vertical sync pulse.

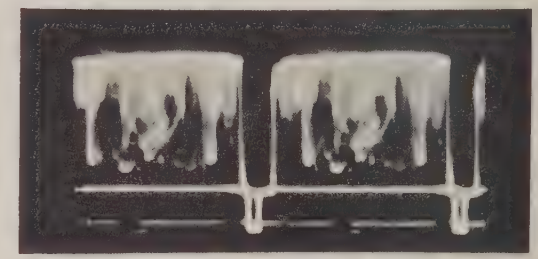


Figure 3-1
Composite TV waveform showing video information, horizontal interval, and horizontal sync pulse.

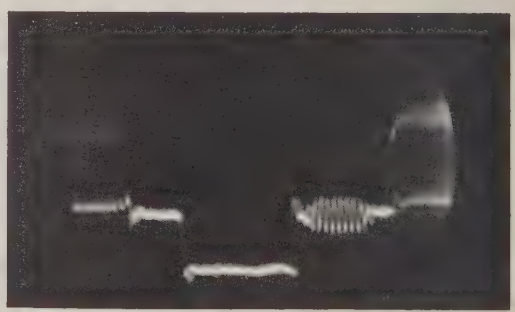


Figure 3-2
Expanded horizontal interval, showing sync pulse and color burst signal.

Figures 2 and 3 show photographs of the composite video signal and typify what the composite video waveform looks like as it travels through the video amplifier of a TV receiver.

Television service technicians may profitably devote time to the study of waveforms by setting up a TV receiver known to be in good operating condition and noting the waveforms on the VIZ WO-527A Oscilloscope at various points in the video amplifier. Waveforms similar to those shown may be obtained as follows:

1. Tune the receiver to a television signal.
2. Rotate the scope INTENSITY control clockwise.
3. Set the SWEEP TIME/DIVISION switch to "TV V".
4. Set the TRIG SOURCE switch to "INT".
5. Adjust the INTENSITY and FOCUS controls for the desired brightness and best focus.

Figures 4 and 5 offer comparisons between normal and mal-functioning sync pulses.

Any deviation of the shape and size of the sync pulses at the CRT socket indicates trouble somewhere in the signal path from the tuner to the CRT.

When it becomes necessary to localize a defective stage within the signal path before the video detector diode, it is essential that a detector probe be used with the WO-527A. The VIZ WG-478 direct cable and the VIZ WG-434A Video/Chroma Band-Pass Detector adapter are available as accessories for this purpose.

If a fixed signal source is desired for trouble shooting, the VIZ WR-515A Master Chro-Bar Generator delivers stable RF, IF and Video information to the receiver. This can be

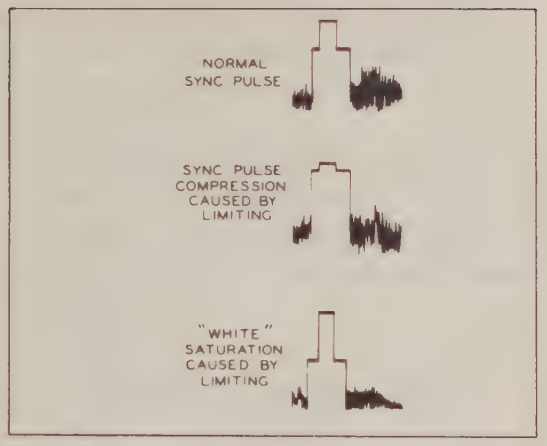


Figure 5

valuable and time saving to the service technician in localizing the receivers problem.

TV ALIGNMENT

Complete realignment of a color TV receiver should seldom, if ever, be necessary. In most instances, an alignment *check* may be all that is necessary, or realignment of only a portion of the receiver. In any case, care must be taken to insure the best possible results.

When preparing for RF tuner alignment, the manufacturer's recommendations should be followed closely. The

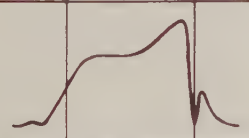
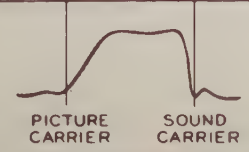
NORMAL HORIZONTAL PULSE	CIRCUIT FAULT	HORIZONTAL PULSE DISTORTION	OVERALL FREQUENCY RESPONSE OF RECEIVER	EFFECT ON PICTURE
	NORMAL CIRCUIT			PICTURE NORMAL
	LOSS OF HIGH FREQUENCIES			LOSS OF PICTURE DETAIL
	EXCESSIVE HIGH-FREQUENCY RESPONSE, NON-LINEAR PHASE SHIFT			FINE VERTICAL BLACK & WHITE STRIATIONS FOLLOWING A SHARP CHANGE IN PICTURE SHADING
	LOSS OF LOW FREQUENCIES (IN THE RANGE ABOVE 15 OR 20 KC)			CHANGE IN SHADING OF LARGE PICTURE AREAS; SMEARED PICTURE.

Figure 4

test equipment that will be required is listed as follows:

1. Oscilloscope (VIZ WO-527A)
2. RF/IF Sweep-Marker Generator (VIZ WR-514A) or similar
3. BIAS Supply for RF & IF AGC Clamping
4. VIZ WR-525A Marker Signalyst
5. VTVM (VIZ WV-98C, WV-510A, or equivalent)

Complete tuner alignment includes setting the oscillator frequencies for each channel, setting one or more traps, adjusting RF amplifier tracking, and obtaining response curves of proper shape, bandwidth and gain. Most tuners simply require touch-up alignment where only a few of the above adjustments are necessary.

An illustration of equipment hook-up for RF tuner alignment of a typical TV receiver is shown in figure 6. Follow the service note instructions for disabling the horizontal deflection circuits, clamping the AGC lines, and applying external bias.

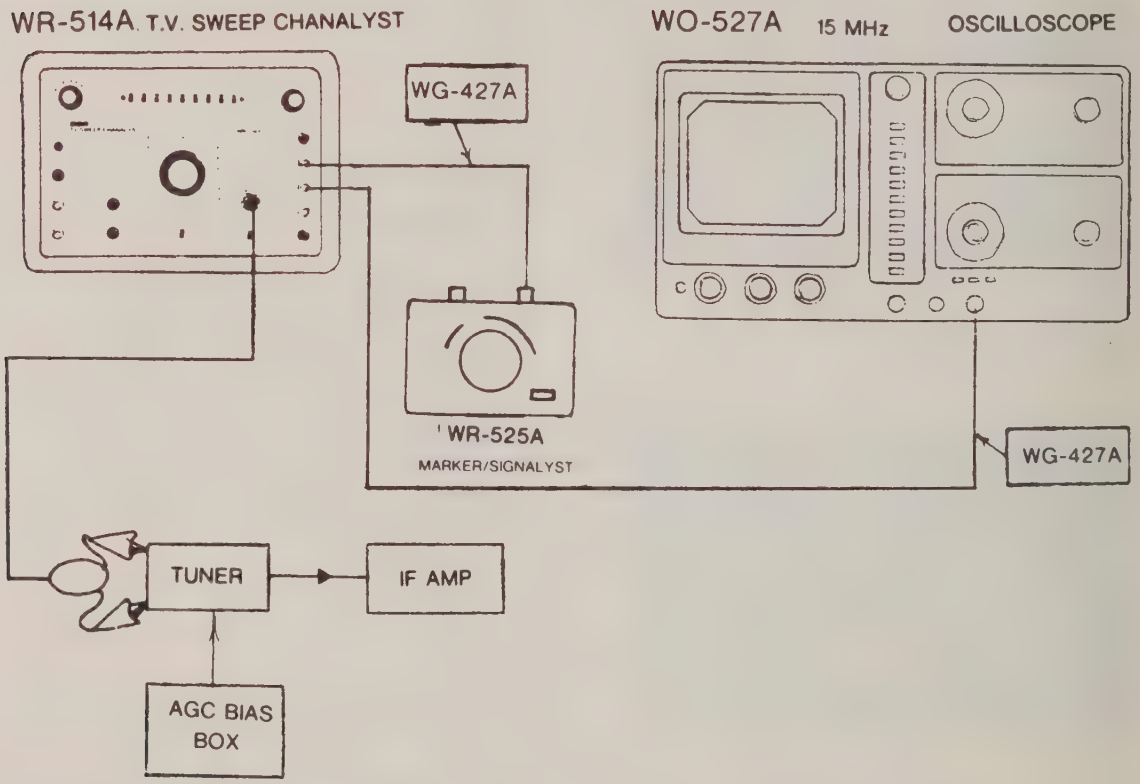


Figure 6
Equipment set-up for RF tuner alignment.

LINK, TRAP, & IF AMPLIFIER SWEEP ALIGNMENT

The equipment set-up techniques described in this section are fairly typical for alignment of the link, traps, and IF amplifier circuits of recent color television receivers. Of course, specific instructions provided in the service data for the particular receiver should be followed.
NOTE: In some solid-state receivers, the link adjustment has been eliminated mainly due to IF input trap filters and a lower input impedance into the IF system.

PRELIMINARY—A typical equipment set-up is shown in figure 7. The VF/IF sweep signal is connected to the mixer input test point of the tuner. For alignment of the tuner link circuit, the output from the receiver is taken at the collector (or plate if in a tube set) of the first IF amplifier using a link detector test block as specified in the service data. For alignment of the IF amplifiers, the demodulated output is taken from the video detector.

PROCEDURE:

1. Disable the AGC and horizontal deflection circuits, apply proper bias voltages, and otherwise prepare the chassis for alignment as described in the service notes. Usually, it is recommended that the tuner be set to the UHF position or to an unused channel to reduce co-channel interference.

2. Set WR-514A controls as follows:
   Channel switch.....to VF/IF
   VF/IF Tuning Control .....to approx. 45 MHz
   Sweep Width Control.....to mid-range
   Demod Amp/scope Direct Switch ....to scope direct

3. Rotate the vertical amplitude fine adjustment control of the WO-527A to maximum clockwise position.
   VERTICAL VOLTS/DIVISION.....to ".1 VOLT"
   DISPLAY .....to "TV LINE"
   TRIG SOURCE .....to "LINE"
   Horizontal SWEEP TIME/DIVISION .....to ".5m sec"
   Horizontal CAL .....to set sweep width as Desired
   TV LINE SELECT .....to center the display
   INTENSITY, FOCUS, AND POSITIONING CONTROLS .....to produce a suitable trace.

Adjust the generator output level to provide a trace with the peak-to-peak voltage level specified in the service data. The sweep signal level must be kept low enough that the amplifier does not become overloaded, thus flattening the top of the curve or otherwise distorting the trace.

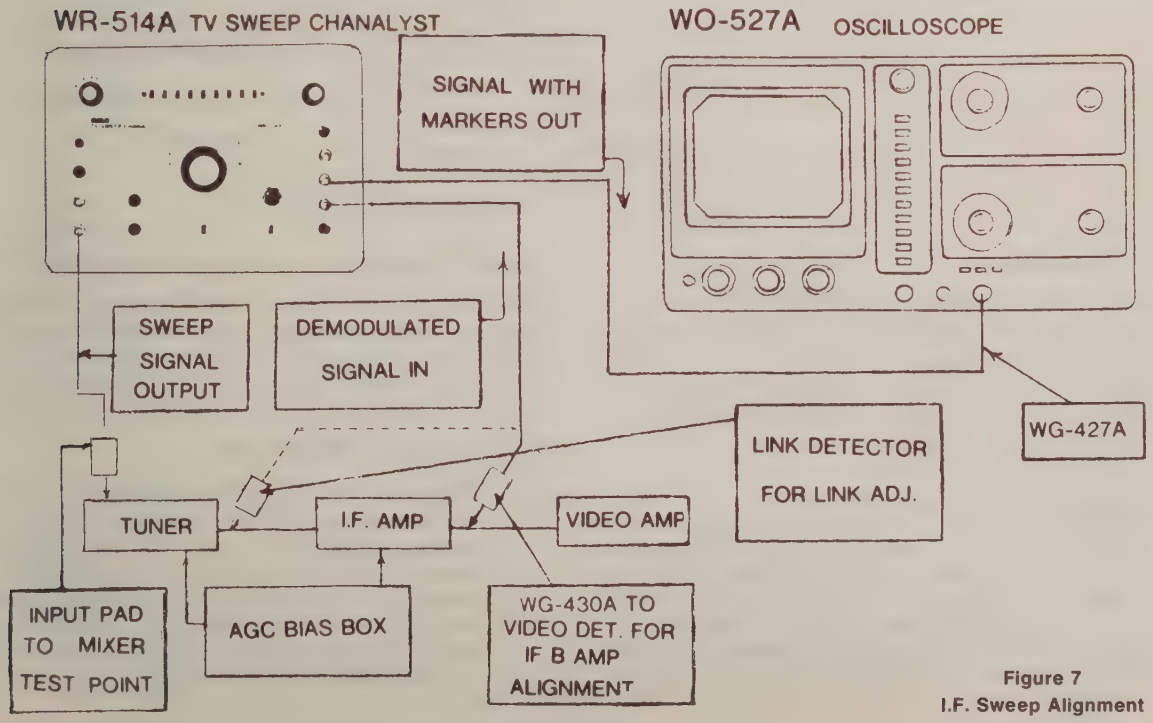


Figure 7
I.F. Sweep Alignment

Set-up the VIZ WR-514A TV Sweep Channalyst according to its instruction manual under link adjustment. Turn on the 42.17 MHz marker. Set link adjustments to provide a suitable curve. Figure 8 illustrates a properly adjusted link curve in a typical receiver.

The effect of each link adjustment for most receivers is listed below:

Mixer output coil .....Relative marker amplitude
Link Coupling Capacitor.....Bandwidth
First IF input Transformer.....Curve Shape

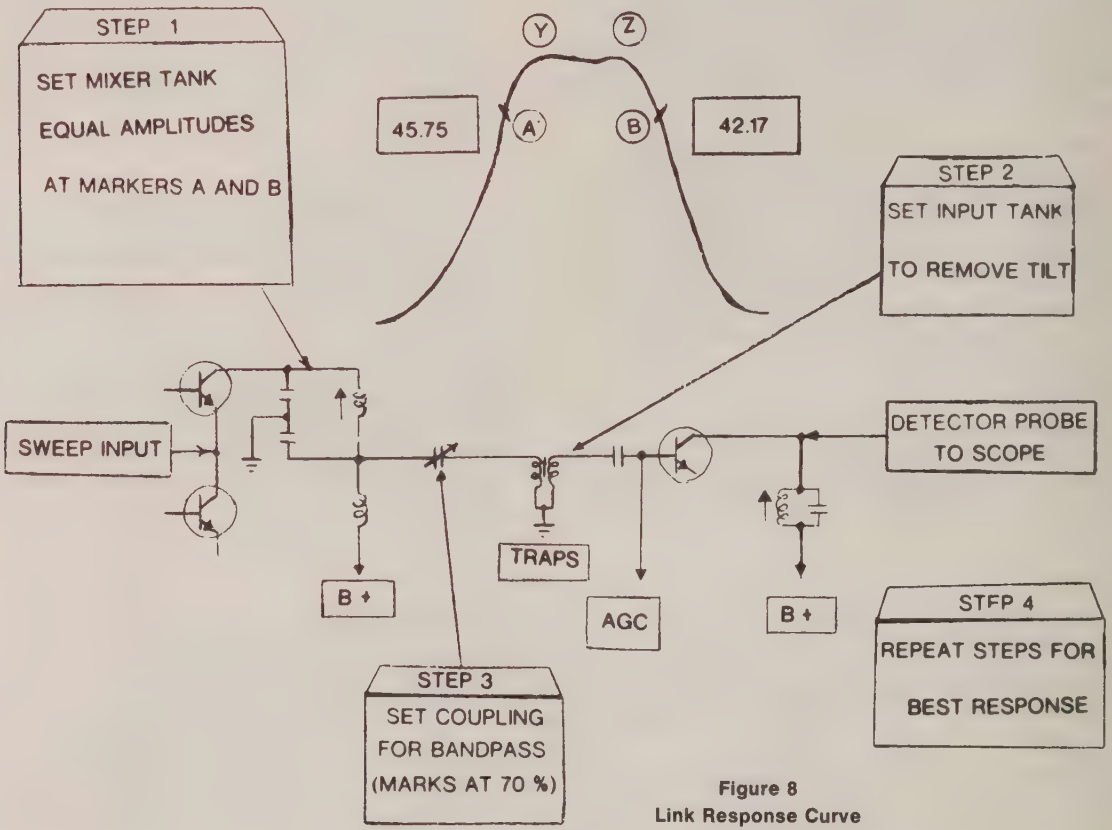


Figure 8
Link Response Curve

TRAP ADJUSTMENT

The WO-527A Oscilloscope can (in conjunction with a TV channel generator such as the VIZ WR-514A Sweep Channalyst) be used to observe the peaking or nulling of the traps/tuning coils. For complete details, it is suggested that the oscilloscope user refer to the manufacturer's TV alignment procedure. (See Figure 9)

IF AMPLIFIER ALIGNMENT

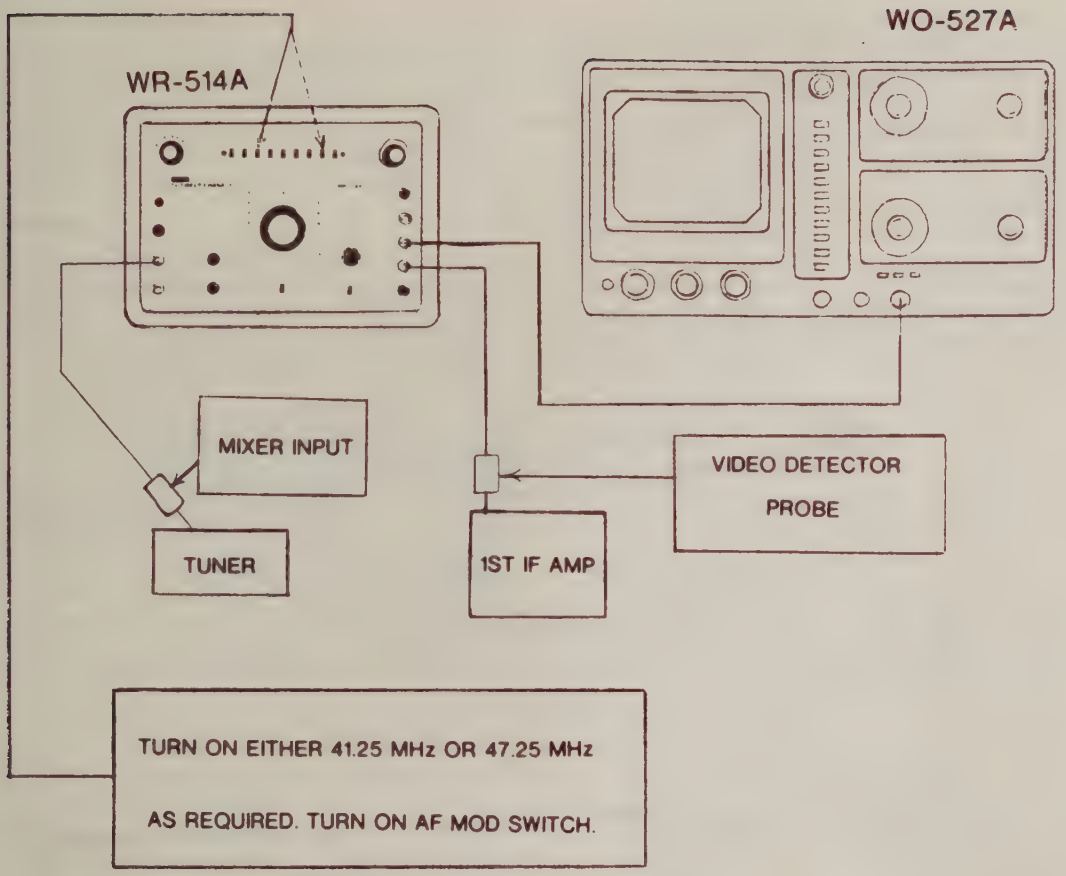
Set up the equipment as outlined in Figure 7. Adjust traps, IF coils and transformer for an IF response curve as described in TV service data. Typical IF response curves are shown in Figure 8. Figure 10 shows a typical equipment set-up for an overall alignment check of a TV receiver along with picture and sound carrier frequencies for each (VHF) channel.

SOUND IF AND 4.5 MHz TRAP ADJUSTMENT

The sound IF coil and the sound demodulator can be aligned simply by using a broadcast station signal. Connect a DC Voltmeter or VTVM, (VIZ WV-98C, WV-510A, or similar) across the discriminator coil and adjust the sound IF coil for maximum distortion-free sound level.

4.5 MHz TRAP ADJUSTMENT

1. Prepare chassis for alignment as described in the TV service data. Connect a demodulator probe such as a VIZ WG 449A, 4.5 MHz Trap Probe and use as specified in the Trap Probe instruction sheet, connect a demodulator probe as specified in the TV service data. Connect the chroma output test point to the demodulator input connector of the VIZ WR 514A TV Sweep Channalyst or equivalent.



Aligning 41.25 and 47.25 MHz Traps

Typical I.F. curves for two types of receivers.

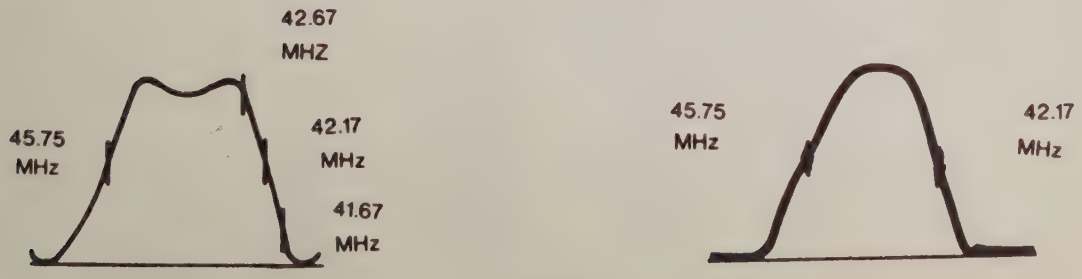
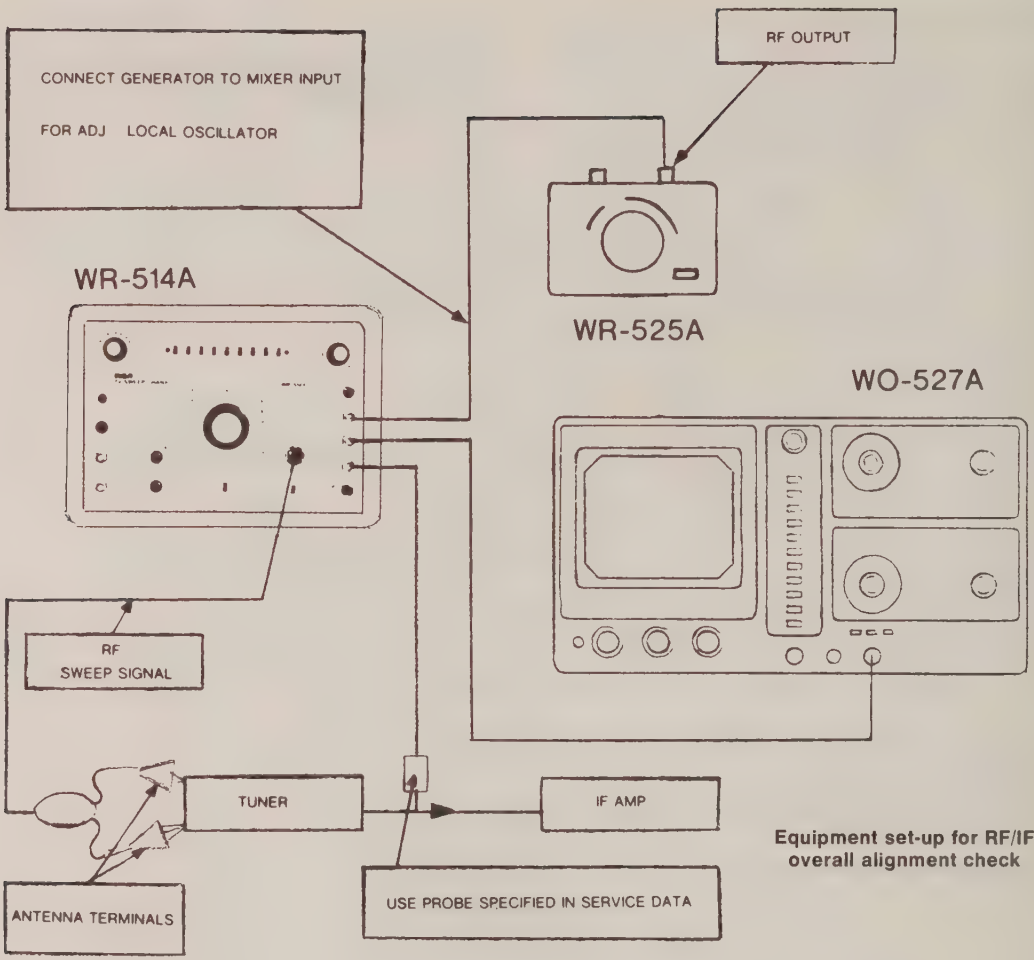


Figure 9



Equipment set-up for RF/IF overall alignment check

VHF TELEVISION FREQUENCIES

Channel Number	Picture Carrier Freq. MHz	Sound Carrier Freq. MHz	Receiver R-F Osc. Freq. MHz (Zero Beat)
2	55.25	59.75	101
3	61.25	65.75	107
4	67.25	71.75	113
5	77.25	81.75	123
6	83.25	87.75	129
7	175.25	179.75	221
8	181.25	185.75	227
9	187.25	191.75	233
10	193.25	197.75	239
11	199.25	203.75	245
12	205.25	209.75	251
13	211.25	215.75	257

Figure 10

2. Turn on the (4.5 MHz) and (AF "Mod" switch). Adjust the "marker out" level control to provide a scope trace with suitable amplitude.
3. Adjust 4.5 MHz trap until it is centered on the 4.5 MHz marker. If the trap is off-frequency, the picture may have sound bias. If the trap is set too low, the chroma response will be distorted.

AFPC ALIGNMENT

When the Automatic Frequency and Phase Control (AFPC) circuit in a color TV receiver is adjusted properly, the tint control will have sufficient range to handle all variations of hue in the transmitted picture; the hue or tint control will change only the hue and not the intensity; color sync will not be lost on weak signals; and color balance of the picture will not change with varying luminance settings. The AFPC alignment procedure recommended by most color TV manufacturers uses a Color Bar Generator (VIZ WR-515A, WR-538A, or similar) as a signal source and a VTVM (VIZ WV-98C, WV-510A or similar) for reference in adjusting the 3.58 MHz. oscillator and the phase detector transformer. An oscilloscope is often used to check the alignment of the phase detector transformer. The usual procedure for adjusting the reactance coil is to ground the reactance tube input, then set the coil for zero-beat of the color signal as observed on the receiver screen or "test jig" if you have the color chassis on the bench.

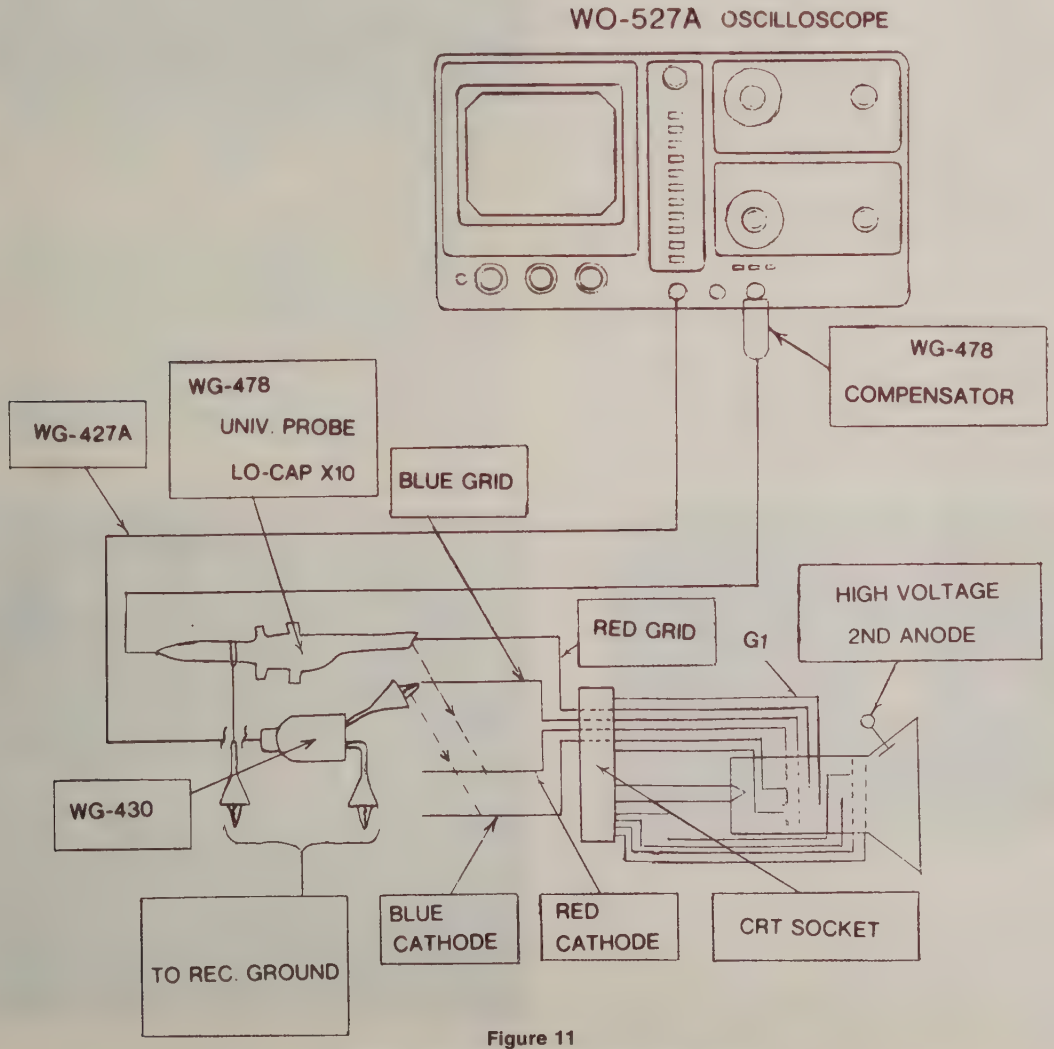


Figure 11
Typical vectorscope application hook-up.

AFPC or (ACC) ALIGNMENT OF SOLID-STATE CHASSIS using the WO-527A Oscilloscope and VIZ WR-515 Master Chro-Bar Generator.

1. Deactivate the chromatic or ACT switch on the TV receiver.
2. Set the ACC, APC, color level, and color-killer or color threshold controls to mid-range.
3. Set the TV receiver tuner to an unused (UHF) channel.
4. Advance the color threshold (color killer) contol until colored snow is observed on the screen.
5. Decrease the color threshold (color killer) control until the colored snow disappears.
6. Now set the TV receiver tuner to the channel corresponding to the color Bar Generator (VIZ WR-515A or WR-538A) R.F. output frequency. Tune the receiver and the Color Bar Generator for best possible color bars and set-up the WO-527A as a vectorscope as described in Figure 11.
7. Remove the color video sampling information from the 3.58 MHz subcarrier regenerator by grounding its input.
8. Observe the WO-527A (set-up as a vectorscope) and adjust the APC control for a stationary or the slowest rotating petal pattern possible while turning the chroma level control on the Chro-Bar Generator (VIZ WR-515A) counter clockwise to reduce chroma input until the petal pattern is barely visible and stationary. See Figure 12.

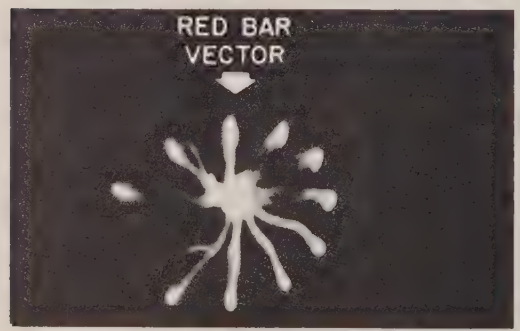


Figure 12

9. Disconnect the ground lead to the subcarrier regenerator input.
10. Adjust TV controls for a normal color picture.
11. Reduce the "color level" control on the receiver to slightly less than normal color levels.
12. Connect the ground lead to the color subcarrier-regenerator input.
13. Short the two ACC inputs to the demodulators together observing any change in the color.
14. Adjust the ACC control until there is no change in the color level of the petal pattern as observed on the WO-527A.
15. When Step 14 is completed, removed jumper from the ACC inputs.

TESTING YOKES, FLYBACK TRANSFORMERS, AND COILS

A task occasionally confronted by TV service technicians is to determine whether a yoke, flyback transformer, or coil is defective. Of course, if the component is completely open or shorted, it can be easily determined by a simple voltage or resistance measurement. The problem may not always be that obvious, because the coil may have just a few shorted turns or a high resistance condition.

The VIZ WO-527A Oscilloscope can be used to perform a "ringing" test on the horizontal and vertical deflection circuit components. In this procedure, a pulse obtained from the oscilloscope sweep circuit is applied to the component under test. The condition of the component can then be evaluated by the amount of damping observed in the waveform. Typical waveforms obtained from a good component and one that has shorted turns are shown in Figures 13 and 14, respectively.

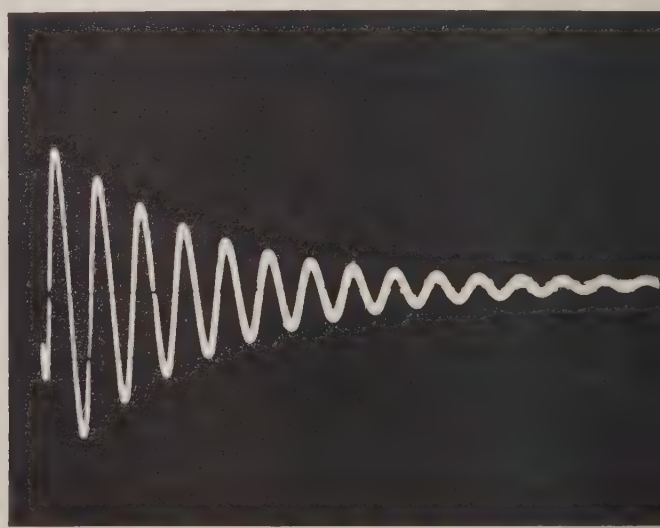


Figure 13

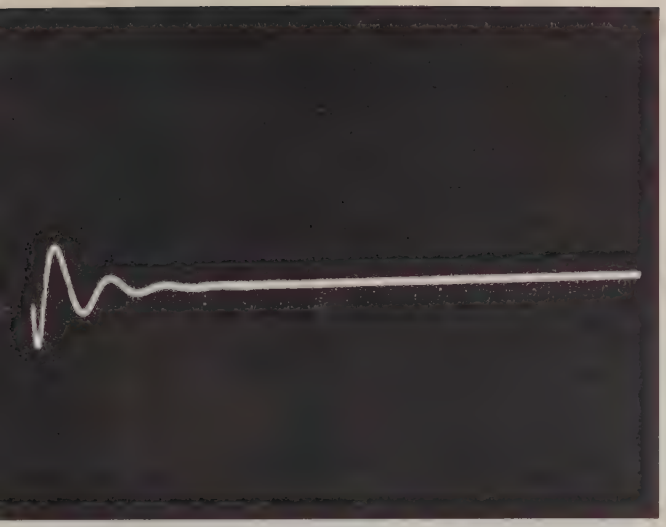


Figure 14

No internal connection or modification to the WO-527A is necessary. A suitable pulse for ringing tests can be obtained at the "Z Axis" connector located within the line cord storage compartment at the rear of the scope. Simply connect the WG-478 Universal Probe in its X10 L0-Cap configuration and its ground lead across the component under test. Then connect a lead from the "Z Axis" connector, through a 68 pf capacitor to the same test point as the probe tip. See Figure 15. NOTE: Power is *NOT* applied to in-circuit components being tested in this manner.

To obtain reliable test results, simply compare the ringing waveform obtained from the component being tested with the waveform from a duplicate component that is known to be good. To gain experience in evaluating the ringing waveform, it is helpful to try the procedure several times, both with good components and those that have purposely been shorted with various resistances.

There are many times, however, when a duplicate is not available for this comparison. Fortunately, there are other testing techniques that can be used to help determine if a component is defective even though a "normal" ringing waveform is produced. These techniques are explained below in the instructions for testing a particular type of component.

Although many components can be tested "in circuit", it may be necessary to remove them especially in solid-state circuits where the semiconductor devices may have a loading effect on the component.

PROCEDURE:

1. Remove power from the component or circuit to be tested. Do not apply power to the circuit at any time during the test procedure.
2. Connect the Universal Probe WG-478, in its X10 Lo/Cap configuration, along with its ground lead, across the component under test.
3. Connect a lead to the "Z Axis" connector at the rear of the scope. Connect a 68 pf capacitor from the end of the lead to the probe tip connection point.
4. Turn on the scope. Set the DISPLAY switch to "NORM", sweep switch to "OUT AUTO," and TRIG SOURCE switch to "INT". The TV LINE SELECT control should be adjusted for a display that exhibits the largest amplitude. Adjust the SWEEP TIME/DIVISION switch to display the complete dampened waveform. Turn the (Sweep time. Div) CAL control fully clockwise. Adjust the (Vertical Volts/Div) CAL control fully clockwise. Adjust FOCUS, INTENSITY and both position controls for the most suitable display.

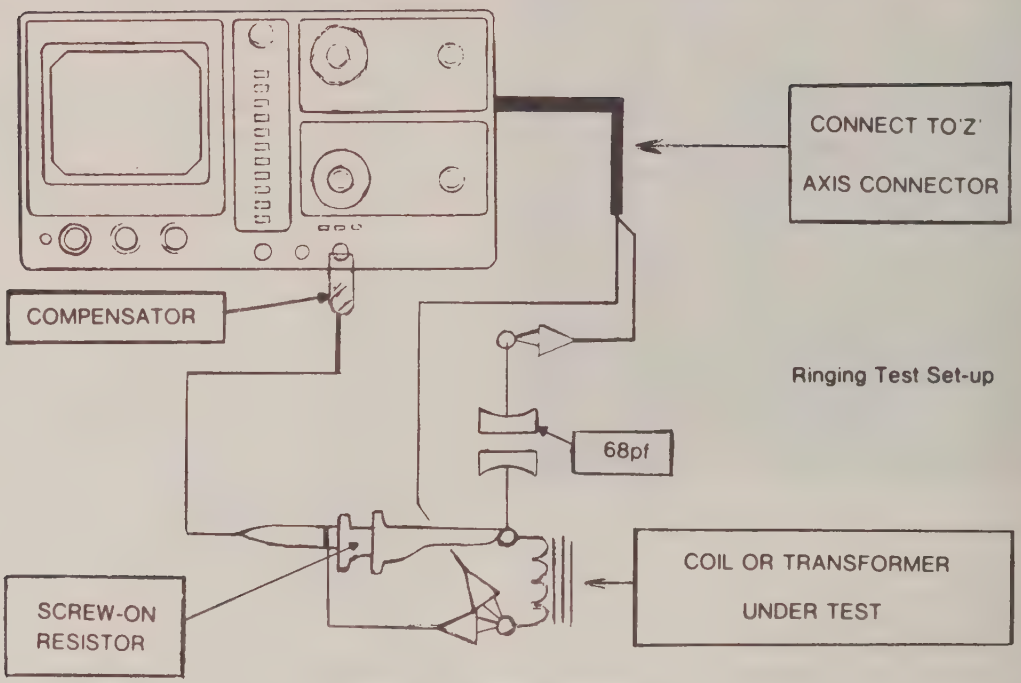
If the component is open or is badly shorted, it will not be possible to obtain the correct waveform.

HIGH-VOLTAGE TRANSFORMER (FLYBACK)

To test a High-Voltage transformer, remove the horizontal output and the high-voltage rectifier tubes, or equivalent leads in semiconductor circuits. Using the procedure described earlier, obtain a ringing waveform across the transformer primary. Connect a short across the filament winding. If a significant change in the waveform is noted, the transformer is probably good. Little or no waveform change indicates that the transformer is defective.

YOKE

To test the horizontal windings of the deflection yoke, disconnect the yoke from the circuit. With the same procedure described earlier obtain a ringing waveform across the coil winding. The horizontal winding of the yoke consists of two sections. Alternately short each section. If the winding is good, the effect on the waveform should be the same as each section is shorted. To test the vertical windings of the deflection yoke, disconnect the yoke from the circuit and remove the damping resistors. Check the vertical windings using the same techniques described above for testing the horizontal windings.



Ringing Test Set-up

Figure 15 Ringing Test Set-up.

COILS

To test the width, liniarity, and focus coils, obtain a ringing waveform across the coil winding as previously described, then make a shorted loop at one turn of the wire, and pass the loop over the coil. If the wire loop causes a significant change in the waveform, the coil is probably good.

OBSERVING TV VITS PATTERN

(Vertical Interval Test Signal)

Most television broadcasting stations are now including a Vertical Interval Test Signal (VITS) in their transmissions. The VITS occurs only during the vertical retrace, or blanking interval and therefore does not effect the television picture. You can observe these signals on the television screen as a series of white dots and lines in the bar area at the top of the picture. On most sets, it will be necessary to adjust the "Vertical Hold" or "Vertical Height" control so that this area is visible. The basic purpose of the "VITS" is for use by the broadcast engineers. They monitor these test signals to be sure the quality of their transmission meets established standards. These signals can also be used by the television service technician to provide a guide as to the performance of the TV receiver, and as an aid in localizing defective stages in sets that have video problems.

The portion of the VITS waveform that is most useful as a reference for TV service is the "Multiburst" (See Figure 16.) The multiburst consists of a sequence of sine-wave

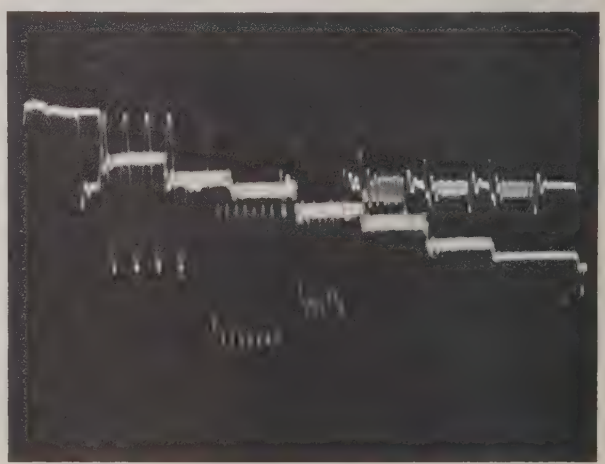


Figure 16

frequencies of 0.5, 1.5, 2, 3, 3.6, and 4.2 MHz. The amplitude of the various frequencies are at the same level when they are transmitted, but are normally attenuated, particularly at the higher frequencies, by the band pass characteristics of the RF and IF amplifiers in the receivers. NOTE: While most broadcasting stations use the type of VITS patterns shown in Figure 17, some may use a special VITS pattern of their own design.

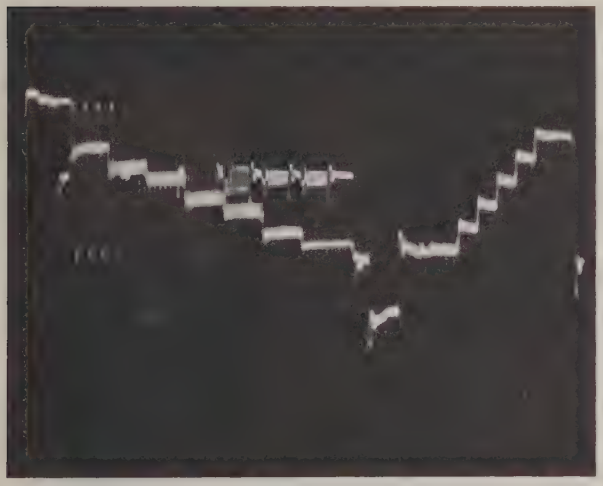


Figure 17

On most color TV receivers there should be at least a 2 to 3V(p-p) composite video waveform present at the output of the video cathode follower in tube sets or the IF emitter follower in solid-state sets. The VITS signal can be seen at these test points using the VIZ WO-527A Oscilloscope.

Set the WO-527A as follows:

VERTICAL VOLTS/DIVISION	"0.5 volts"
SWEEP TIME/DIVISION	"20μ sec"
(Sweep time/Div) CAL	Fully clockwise
DISPLAY	"TV LINE"
Sweep Switch	"IN TRIG"
TRIGGER SOURCE	"INT"
TV LINE SELECT	Adjust to center VITS pattern on the screen

Adjust FOCUS and INTENSITY controls for best display.

TROUBLESHOOTING WITH VITS

1. Figure 18 shows a Vertical Blanking Interval with the VITS on the right side. The Vertical Interval should be used to sync the WO-527A Oscilloscope in order to expand the VITS Pattern for analysis.
2. Check the VITS patterns at the video detector. If they are normal, the problem must occur after the detector, probably in the video amplifier stage.
3. If the VITS are not normal, with parts of the multiburst having much lower relative gain than shown in Figure 17, then the trouble is ahead of the detector.

   Figure 17 shows a normal VITS pattern, while Figure 19, shows a pattern with definite attenuation at the high frequency end of the multiburst.

   In this example, the TV picture had no color. Since the VITS shows low gain in the color passband frequencies at the video detector, the problem is not in the color bandpass amplifier, but must be ahead of the video detector, probably in the IF amplifier.
4. Set the TV receiver channel switch to view the VITS transmitted by other network stations. It will probably be necessary to make slight re-adjustments to the TV LINE SELECT control to keep the pattern locked in. If the VITS on all channels are poor, then the IF amplifier is probably at fault.
5. If the other channels produce a normal VITS signal, the trouble may be in the tuner or antenna system.

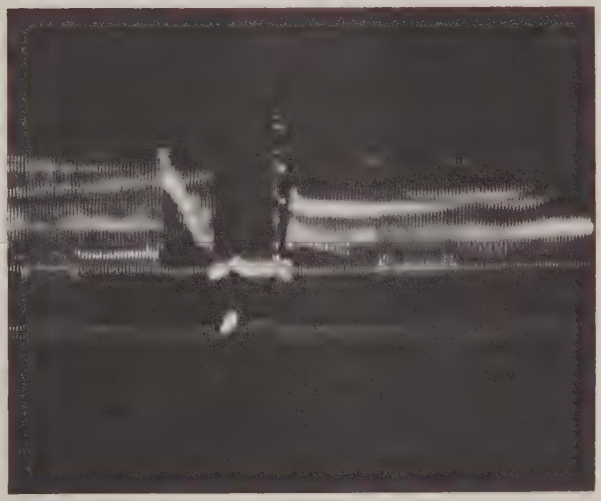


Figure 18
Expanded vertical blanking interval showing vertical sync pulse and VIT signal.

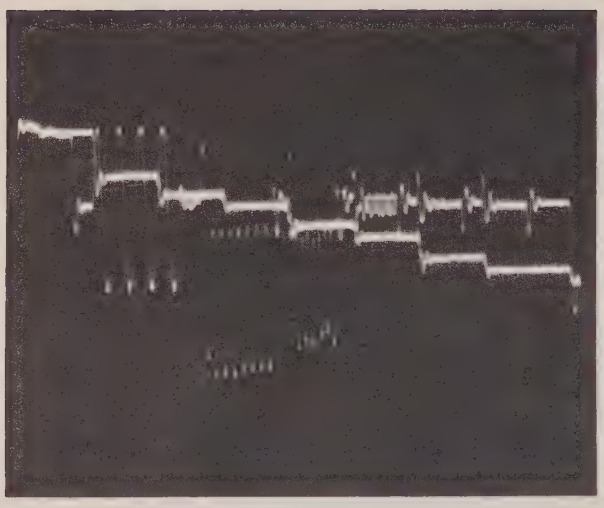


Figure 19

Vector Analysis

To use the VIZ WO-527A as a "Vectorscope" connections are made as follows: (See Figure 11.)

1. Vertical input, through WG-478 X10 Lo-Cap Universal Probe configuration, to red grid or cathode of the TV receiver's picture tube.
2. Horizontal input, through VIZ WG-427A Direct Cable Probe and VIZ WG-430A Direct Cable Adapter, to the blue grid or cathode of the receiver's picture tube.
3. Use a color bar generator such as the VIZ WR-515A Master Chro-Bar/Generator or WR-538A. Feed the RF output to the TV receiver's antenna terminals and adjust the receiver to channel 3. If a generator of another manufacturer is being used, consult the instruction manual of the generator in use for the correct RF output frequency and tune the receiver accordingly.
4. Set the controls of the WO-527A as follows:

VERTICAL VOLTS/DIVISION	"20 Volts"
(Vertical) CAL	Fully clockwise
(Sweeptime/Div) CAL	Fully counter clockwise
DISPLAY	"EXT" push button
TRIGGER SOURCE	"EXT" ÷ 10 push button
TV LINE SELECT	N/A

Adjust the FOCUS and INTENSITY controls for the best display. Adjust the Horizontal CAL control and the VERTICAL VOLTS/DIVISION control for best circular "Rosette" petal pattern as projected in figure 12.

The connections to the picture tube depend primarily on how the chroma and black and white information is matrixed within the color TV receiver under test.

In order to understand the "Vector" pattern being displayed, you should check for the presence of the following information:

1. Demodulation angle
2. The degree of chroma bandpass alignment
3. Presence of the burst signal
4. Chroma sync stability
5. Hue or tint range (phase)
6. Chroma amplitude
7. The degree of chroma AFPC (Automatic Frequency and Phase Control) alignment
8. The degree of color killer or threshold adjustment

AUDIO

The oscilloscope is probably the most useful and versatile of all the instruments used by the electronic technician/engineer in making audio tests and measurements. The following describes some of the ways the VIZ WO-527A OSCILLOSCOPE may be used by the Audio Specialist.

USE OF OSCILLOSCOPE AS A PEAK READING VOLTMETER AND PROGRAM MONITOR

One of the simplest and most interesting uses to which an oscilloscope can be put is to monitor the output of an audio amplifier carrying program material. In many applications, such as broadcasting or recording, certain peak voltage levels should not be exceeded or excessive distortion will result. The instantaneous visual indication of transient voltages as seen on the oscilloscope makes it considerably superior to conventional meters.

OVERLOAD INDICATION

Using the oscilloscope as an overload indicator requires the use of a special screen over the face of the scope. To make such a screen, draw two parallel, horizontal lines on a celluloid sheet separated by some convenient distance, such as six centimeters. A calibration voltage is then applied to the scope input and the input level adjusted so that the peaks of the signal trace just touch the two parallel lines. If the scope is then used to monitor program material, any traces appearing *outside* of the two parallel lines indicate output exceeding that of the calibrating voltage, and the amplifier gain may be reduced accordingly.

TYPICAL WAVEFORMS IN AUDIO AMPLIFIER

To check the performance of an audio amplifier, a simple set-up is shown in block form in Fig. 20. The source of test signal is desirably an audio generator such as the VIZ WA-504B/44D. However, a 10K ohm potentiometer connected across a 6-volt AC filament supply will do for many purposes.

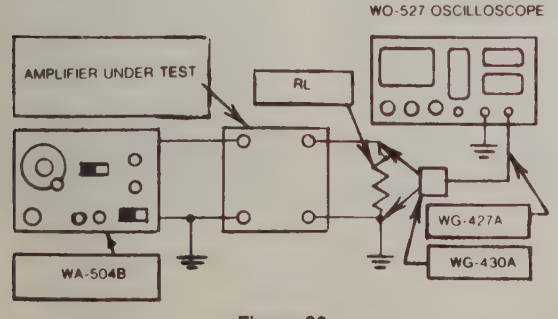


Figure 20

The oscilloscope itself can be used to measure voltage by setting the vertical gain to some convenient value when a known signal is applied, and noting the centimeters of deflection on the screen per input volt.

Referring to the waveform traces, Figure 21, when a sine-wave AC voltage is applied to the amplifier input, the output waveform normally looks like Trace No. 1. As the signal level is increased, over-loading occurs and the amplifier begins to clip one side of the wave as in Trace No. 2. At extreme overload, when the input signal is 5 times the voltage required for normal full output, the amplifier behaves like a square wave generator as in Trace No. 3. The frequency in this case is in the middle audio band, 100 to 2000 cycles.

At low frequencies, overloading may occur due to saturation of the core of the output transformer. This produces a wave of the shape shown in Trace No. 4. With a large output transformer, this type of distortion may not be apparent until the frequency is reduced below 30 or 40 cycles, but with a small transformer saturation distortion may appear as high as 200 cycles.

OUTPUT POWER

Output power of the amplifier (See Fig. 20) is measured by noting the voltage across the load resistor "R", at which distortion of the type of Trace No. 2 or Trace No. 4 begins to be noticeable. the power in watts is then E^2/R where E is the output voltage in volts and R the load resistance in ohms. Because the voltage term is squared, a given percent error in measuring the voltage will create twice as large a percent error in the power, hence accuracy is desirable. The maximum power output of most amplifiers falls off more rapidly at extreme low and high frequencies than does the actual gain at moderate power levels.

FEEDBACK AMPLIFIER OSCILLATION

Negative feedback amplifiers in which the output transformer is included in the feedback loop are prone to oscillate at high frequencies—30 to several hundred kilohertz. A wideband oscilloscope is indispensable in detecting such oscillation. If the amplifier is continuously oscillating it can readily be viewed on the oscilloscope screen when the input signal is turned off. Sometimes the application of an audio input signal will nearly kill the oscillation, leaving only a slight fuzziness on the peaks of the waves as an indication of trouble. Such oscillation can ruin the listening quality of an amplifier, making it

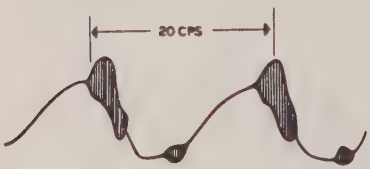
WAVEFORMS

TRACE 1
AUDIO AMPLIFIER UNDER TEST-
NORMAL SINE WAVE OUTPUT FROM
VOICE COIL TERMINALS.

2.
SAME AMPLIFIER-
MODERATE OVERLOAD.

3.
SAME AMPLIFIER-
EXTREME OVERLOAD

4.
TRANSFORMER CORE
DISTORTION.
MAINLY 3RD HARMONIC.



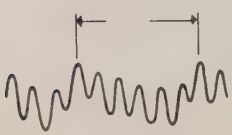
5.
BURSTS OF HIGH-
FREQUENCY OSCILLATION
IN FEEDBACK AMPLIFIER

6.
TRIODE VOLTAGE
AMPLIFIER STAGE,
LARGE SIGNAL BIAS
TOO LOW.

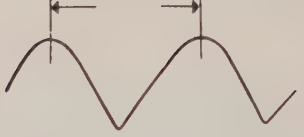
7
SAME STAGE, BIAS
TOO HIGH.

8.
SAME STAGE, BIAS OPTIMUM.

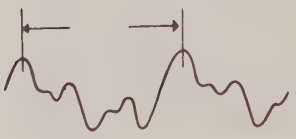
9.
SIGNAL PLUS HUM.



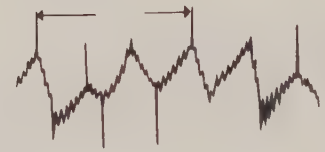
10.
SIGNAL PLUS HUM.



11.
HUM DUE TO HEATER-
CATHODE LEAKAGE IN TUBE.



12.
INDUCTIVE HUM PICKED UP BY
AUDIO TRANSFORMER FROM
POWER TRANSFORMER.



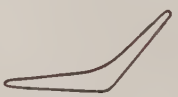
13.
FLUORESCENT LAMP
INTERFERENCE.

14.
X-Y TRANSFER CHARACTERISTIC
OF AMPLIFIER STAGE OF
FIG.3 CORRECT BIAS.

15.
SAME - BIAS TOO LOW.

16.
SAME - BIAS TOO HIGH.

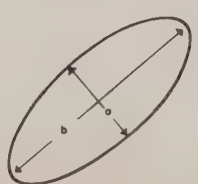
17.
X-Y TRANSFER CHARACTERISTIC
OF IN34 CRYSTAL DIODE.



18.
SAME BUT FREQUENCY TOO HIGH,
SHOWING UNDESIRED PHASE SHIFT.

19
PHASE MEASUREMENT-
HORIZONTAL SIGNAL ALONE.

20
VERTICAL SIGNAL ALONE.



21
BOTH SIGNALS TOGETHER.
RATIO OF AXES OF ELLIPSE
$\frac{a}{b}$ = TANGENT OF HALF THE PHASE ANGLE.

Figure 21

sound fuzzy and rough even though the oscillation frequency is inaudible. The oscillation changes the effective bias on various stages of amplification.

Frequently oscillation shows up in the presence of a low-frequency signal. A typical wave of this sort is shown as Trace No. 5. Bursts of high-frequency are super imposed on the audio-frequency wave. Often this phenomenon appears only under overload conditions at very low frequencies, 20 cycles or so. The safest remedy is to reduce the amount of negative feedback in the circuit under test. Another common remedy is to shunt a few hundred $\mu\mu f$ of capacitance across the collector circuits of the output transistors.

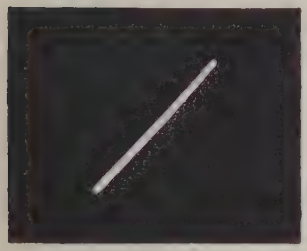
HUM IN AUDIO CIRCUITS

An audio signal sine-wave contaminated by hum shows the typical oscilloscope pattern of two different frequencies added together. This generally looks like Traces No. 9 or 10. Since the oscilloscope sweep cannot be synchronized to both the signal and the hum frequency, only one component of the pattern can be made to hold still; the other moves.

HARMONIC DISTORTION INDICATIONS

A sensitive test for harmonic distortion is to apply the signal from the audio oscillator to one oscilloscope deflection amplifier and the output of the unit being tested to the other. If no phase of harmonic distortion is present, then a straight diagonal line will be traced upon the oscilloscope screen. If harmonic distortion is present, the line will exhibit one or more bends or kinks, and the following scope patterns illustrate some of the various distortions that may be encountered. (See Figure 22)

By taking a celluloid sheet and drawing a straight diagonal line on it with a ruler, and then matching the scope trace as closely as possible to the straight line, it is possible to detect harmonic distortion as low as two or three percent. For greatest ease in detecting distortion, the phase shift present in the system should be as low as possible or an oval trace will result instead of a line. If a low distortion signal source is used, a phase shifting network may be used between the audio oscillator and the scope in order to cancel out phase distortion taking place in the equipment under test, and an example of this is shown in Figure 23.



Trace produced by amplifier having neither phase or harmonic distortion

Trace showing both 2nd and third harmonics

Trace showing predominately third harmonic distortion

Trace showing severe high order distortion at low levels as well as overload on positive peaks

Figure 22

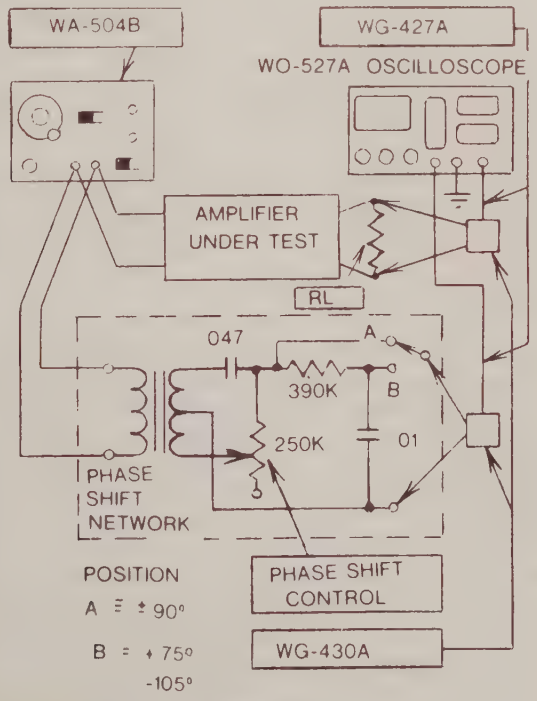


Figure 23

INTERMODULATION TESTING

Through the addition of three resistors and three condensors, the oscilloscope can be used as a very effective means of detecting intermodulation distortion occurring in audio equipment. To make intermodulation tests, two tones are applied to the equipment being measured. One of these may be sixty Hz. obtainable from the power line through an isolation transformer, and the other a high frequency tone of between two thousand and ten thousand Hz. These two tones are usually mixed together with the low frequency being approximately four times the amplitude of the high frequency. (See Figure 24)

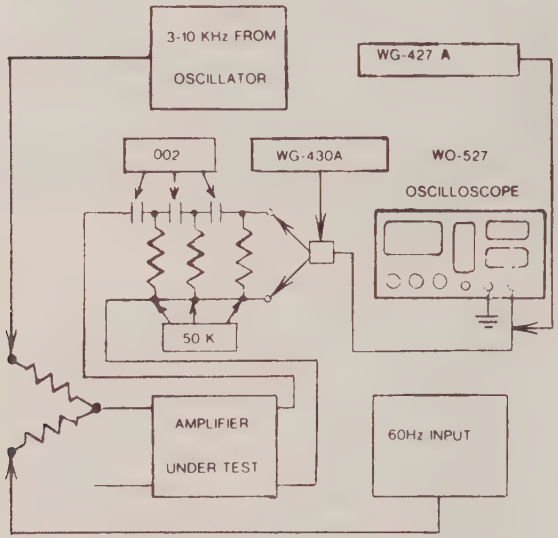
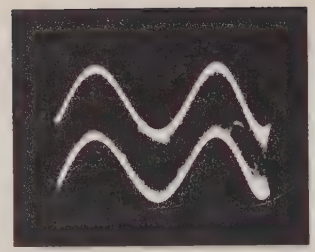


Figure 24

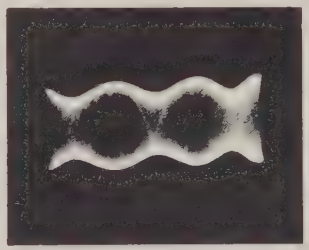
The output of the equipment being tested is then applied to the scope input through a simple RC high pass filter, the complete setup being shown in the accompanying diagram, and the pattern traced upon the screen may then be examined for any modulation that may have been produced by the equipment under test. Following are shown three of the typical patterns that may be produced. (See Figure 25)

The oscilloscope can indicate several important factors which are not normally discernible with the average intermodulation meter. It will show whether positive or negative modulation is taking place and what type of



Pattern of test signal with high and low frequencies mixed in one to one ratio

Output of high pass filter when no distortion has been introduced by equipment under test



Pattern of intermodulation caused by second harmonic distortion in equipment under test. Approximately 25% distortion

Figure 25

harmonic distortion is apt to be accompanying the IM distortions. For example, second harmonic distortions will cause the envelope shape to resemble the waveform of the low frequency component, while third harmonic distortion will make the envelope shape resemble the low frequency component if it had been passed through a full wave rectifier. In addition, the individual cycles of the high frequency component may be examined to see if severe harmonic distortion is occurring here in addition to modulation.

The excellent sensitivity of the WO-527A Oscilloscope means that the intermodulation tests may be made at very low power levels as well as at high output. This can be very desirable due to the fact that with modern loudspeakers a signal level of a fraction of a milliwatt may be highly audible and low distortion at such intensities may be essential to good listening. Likewise, the high sensitivity and high input impedance of the oscilloscope means that voltage amplifier stages and preamplifiers may be tested to locate sources of distortion, or if desired, an entire reproducing system may be tested by the intermodulation technique.

X-Y GRAPHS WITH THE OSCILLOSCOPE

Instead of using the sweep circuit built in the oscilloscope, an external signal can be fed into the horizontal amplifier. A display very useful in audio work is produced when the horizontal input is taken directly from the output of some circuit under test, which is fed from the same signal source. Fig. 26 shows a resistance-coupled amplifier stage under test, similar to Fig. 20, except that it is arranged for an X-Y display. The line appearing on the oscilloscope screen shows the relationship between the input signal and the output signal of the test circuit. When the bias is correct, the graph is a straight line, Trace No. 14. When the bias is too low, the curvature of the transfer characteristic is clearly shown in Trace No. 15. Too-high bias gives curvature on the other end, Trace No. 16. This type of display is a more sensitive indication on non-linear distortion than the conventional time-base display.

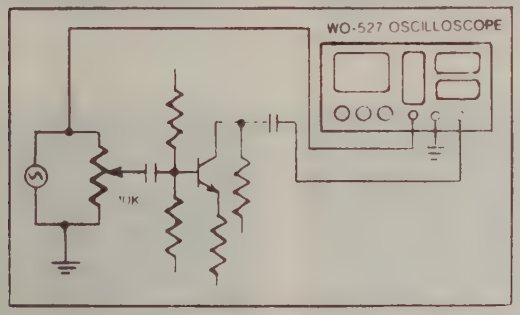


Figure 26

An audio generator is necessary as a signal source because it is necessary to use a frequency at which the phase shift of the test circuit is nearly zero. There is always such a frequency, and it is usually between 200 and 1000 cycles.

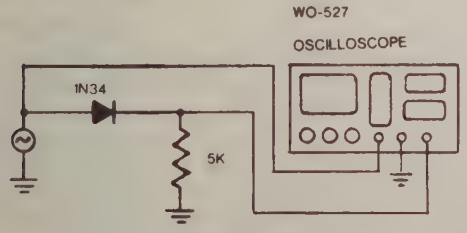


Figure 27

Trace No. 17 shows the transfer characteristic of a crystal diode in the circuit of Fig. 27. Trace No. 18 illustrates the degradation of the display by undesired phase shift, in this case due to using a test signal frequency that is too high.

SQUARE WAVE TESTING

The use of square waves for testing the characteristics of audio equipment has distinct advantages over other methods. A square-wave generator such as the WA-504B/44D or WR 550A and the WO-527A Oscilloscope, when set up as shown in Figure 20 can provide a quick and accurate means of checking an amplifier and its adjustments. In this test setup, it is possible to check simultaneously the amplitude, phase, and frequency characteristics of the amplifier.

The value of the load resistance used depends upon the output impedance of the amplifier. It is important that the correct value be used. For an overall check of amplifier response, the oscilloscope should be connected directly across the load resistance, as shown in Figure 20.

It is desirable to employ square waves of at least two fundamental frequencies. The lowest fundamental frequency should be equal to approximately ten times the low-frequency limit of the amplifier being tested. A 60 Hz square wave should serve to check response from a few Hz to over 1000 Hz. If a square wave having a fundamental frequency of 2KHz is used, the amplifier may be checked through the balance of the audible range.

The square wave generator should be set to the proper frequency and connected to the regular input terminal of the amplifier. The oscilloscope may be connected temporarily directly across the generator for a reference check of the waveform.

Waveform checks can then be connected to various points in the amplifier to determine how each stage is functioning. The effect of various adjustments may be seen on the screen.

Care should be taken to prevent too large a signal from the square-wave generator from overloading the amplifier and causing distortion of the square wave.

At low frequencies (10 to 60 cps), the output signal will appear somewhat as shown in Fig. 28-1, indicating a drop-off in low frequency response, together with some phase-shift. At frequencies in the middle of the response curve, the output square-wave will be perfectly "flat" with sharp corners, as shown in Fig. 28-2. As higher frequencies are used, the square-wave will become more rounded, as shown in Fig. 28-3. The wave form shown in Fig. 28-4 will be obtained at frequencies near the upper end of the response curve.

In order to pass a low-frequency square-wave without "tilt" the amplifier must pass, without phase-shift or drop-off in amplitude, signals down to the fundamental of the square-wave signal used. Thus an amplifier which permits a 50 Hz square-wave to pass without tilt or slant may be considered reasonably "flat" to 50 Hz.

In order to pass a high frequency square wave without too noticeable rounding, the amplifier must pass, without appreciable drop-off, signals to the 11th harmonic of the square-wave signal used. Thus, an amplifier which permits a 5 KHz square-wave to pass without rounding may be considered "flat" to 55 KHz. For practical work, the "tenth" harmonic is usually considered as the upper limit, although a "perfect" square-wave does not contain even harmonic signals (in the example given, the amplifier would be considered "flat" to 50 KHz).

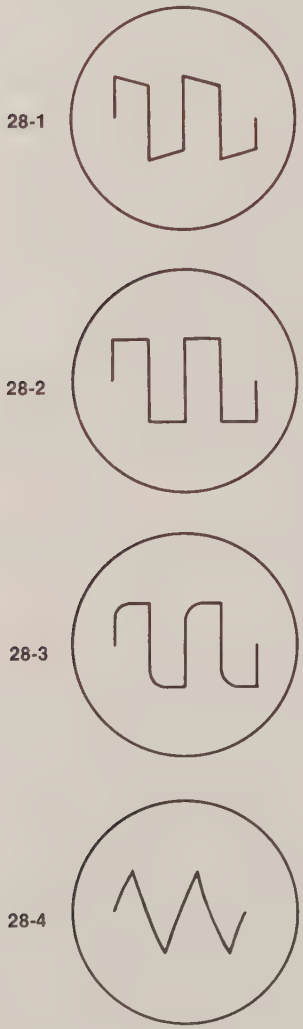
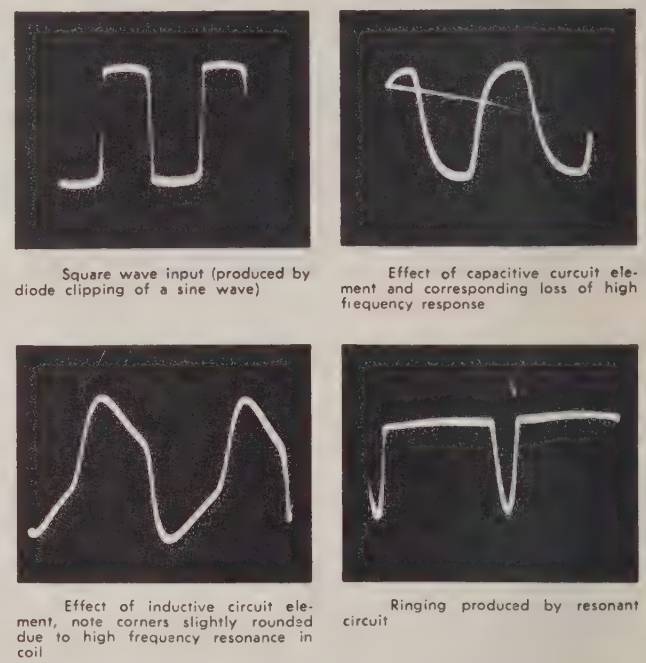


Figure 28

TRANSIENT TESTS WITH THE OSCILLOSCOPE

The oscilloscope is the only instrument used widely in making transient tests. The most common technique is to generate some transient waveform, such as the square wave, and visually examine any distortions that may occur in the equipment being tested. The following pictures of oscilloscope patterns illustrate some of the distortions that may occur frequently. (See Figure 29)



Square wave input (produced by diode clipping of a sine wave)

Effect of capacitive curcuit element and corresponding loss of high frequency response

Effect of inductive circuit element, note corners slightly rounded due to high frequency resonance in coil

Ringing produced by resonant circuit

Figure 29

It is usually considered that transient distortions are apt to be the largest in electro-acoustic devices such as loudspeakers, phonograph pickups, and microphones. The excellent sensitivity of the WO-527A OSCILLOSCOPE means that in many cases the electro-mechanical device being tested may be connected directly to the oscilloscope input. For example, the intensity and duration of loudspeaker resonances may be easily indicated by connecting the speaker voice coil terminals to the scope input and tapping the cone sharply. Similarly, any crystal phonograph pickup and most high impedance microphones will have enough electrical output to produce usable scope traces.

FREQUENCY MEASUREMENT

USE OF THE OSCILLOSCOPE AS A FREQUENCY METER

The WO-527 Oscilloscope calibrated Horizontal time base provides a very direct method of frequency measurement. When the control is in the calibrated position, the horizontal sweep is accurately set to the time (shown on the knob) that it takes the trace to move one centimeter (as shown on the calibrated graticule). By measuring the linear distance of one cycle of a periodic signal, we have the period, P, which relates to frequency f as

$$f = \frac{1}{P}$$

where f is in Hz and P is in seconds.

In addition to this direct method, several other methods of frequency determination are possible with an oscilloscope and those can be very helpful in special situations.

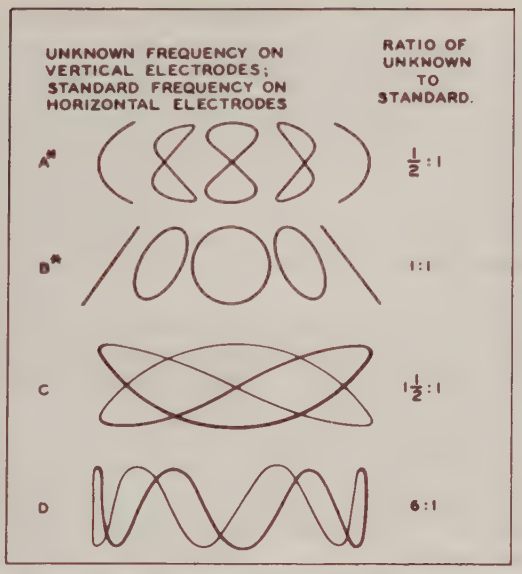
ANOTHER FREQUENCY MEASURING TECHNIQUE

If an accurately calibrated audio oscillator is available, the oscilloscope may be used as a convenient means of determining the frequencies of unknown signals. The simplest way to do this is to set the oscilloscope sweep frequency to its lowest range and mix the unknown signal with that from the audio oscillator in a one to one ratio. The frequency of the audio oscillator is then varied until low frequency beats appear. The point at which the beats are extremely slow or seem to vanish is the point at which the local oscillator frequency is the same as the unknown. However, in order to avoid mistaken readings, the user should be sure that the beats are not being produced by strong harmonics in either waveform.

If it is desired to know the various components of a complex wave, for example one containing frequencies of one hundred and five thousand Hz. then the local audio oscillator may be slowly swept through the audio range and the zero beating with various frequency components noted.

LISSAJOUS FIGURES

Another method of measuring frequency is through the use of the Lissajous figures. In this case the unknown signal is applied to the oscilloscope vertical amplifier and the signal from the local audio oscillator to the scope horizontal amplifier. If the local oscillator is tuned to a frequency twice that of the unknown signal, a figure eight will be formed on the screen, while both frequencies are identical, an oval, or circular pattern will be produced. As in the beat method, mentioned previously, a complex wave may be examined by slowly sweeping the local oscillator through the audio range and noting the points at which oval or circular patterns are produced. Below are several examples of patterns produced by beats and Lissajous figures. (See Figure 30)



*One of the five patterns illustrated appears on the oscilloscope, depending on the phase relationship of the two input frequencies.

Figure 30

As we have seen, an almost perfect circle may be formed on the screen of an oscilloscope by applying sine-wave signal having a 90° phase difference to the horizontal and vertical inputs. This fact may be used to advantage to form a circular time base for comparing the frequencies of a known and an unknown signal. (See Figure 33)

The known signal is applied to a simple R-C phase shifting network to obtain signals which are 90° out-of-phase. These signals are applied to the horizontal and vertical inputs of the scope to form a circular pattern. The unknown signal is then applied to one input along with the known signal. The resultant is a gear-toothed pattern, with the number of "teeth" on the pattern giving the ratio between the known and unknown signals.

For demonstration purposes, the circuit shown in Fig. 31 may be used. R^1 and C^2 form a phase-shifting network for the known low frequency signal. Connections to the oscilloscope are as shown.

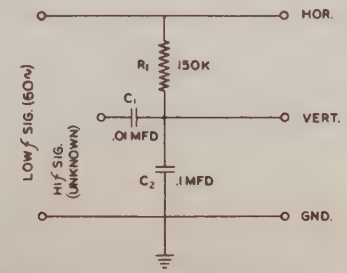


Figure 31

The unknown high frequency signal is applied to the VERT. INPUT of the oscilloscope along with the "phase-shifted" low frequency signal. Capacitor C^1 permits application of the high frequency unknown signal, yet offers sufficient impedance to the low frequency signal to prevent interaction between circuits. As far as high frequency signals are concerned, C^1 and C^2 form a simple capacitive voltage divider. (For best results, the amplitude of the high frequency signal should be low compared to the signal used to form the circular time base).

With the component values given, a 60 Hz signal may be used as the low frequency signal to form the circular time base. A high frequency signal may be obtained from the VIZ WA504B/44D Audio Generator.

The pattern formed will appear somewhat similar to the one shown in Fig. 32 with the number of "teeth" in the gear representing the ratio between the frequencies of the signal forming the basic circular pattern and the unknown signal.

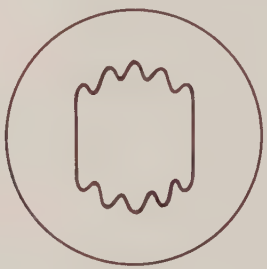


Figure 32

As can be seen, this method permits comparison of signals having a wide ratio. Ratios of 1:15 and 1:20 are not uncommon. Such ratios would be difficult to determine, to say the least, using conventional Lissajou figures. The pattern would become so complex that analysis would be virtually impossible.

The number of "teeth" are sometimes difficult to determine unless special care is taken to "stop" the tendency of the pattern to rotate. This is best accomplished by very careful adjustment of the exact frequencies of the two signals being compared. If the unknown signal is fixed, the low frequency signal used to form the basic circular pattern is varied slightly.

ADDITIONAL EXPERIMENTS

If the circuit in Fig. 33 is used, and the high frequency signal varied over a wide range, as well as the relative amplitudes of the high and low frequency signals, extremely interesting patterns may be formed. The simple

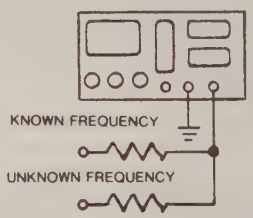


Figure 33

"gear tooth" pattern may be changed into rings, into elongated cylinders, or into other patterns.

Unusual effects may be obtained by reducing the frequency of the "high frequency" signal until it approaches and becomes equal to the frequency of the low frequency signal used to form the basic circular pattern.

Other effects may be obtained by substituting signals other than sine-waves for the high frequency signal. Square-waves, especially, permit the formation of quite distinctive and unusual patterns.

PHASE MEASUREMENT

PHASE SHIFT INDICATION

A knowledge of phase characteristics is becoming increasingly important in audio design and construction, and the oscilloscope makes an excellent method of detecting phase shift over a range of from zero to one hundred eighty degrees.

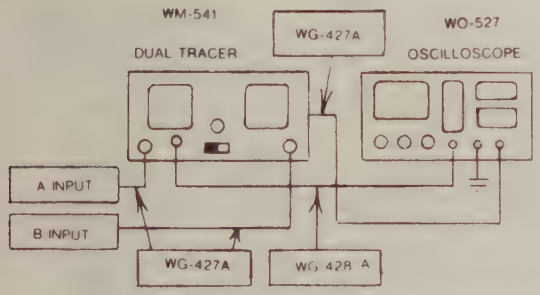


Figure 34

If an Electronic Switch is available, two sine-wave signals may be directly compared for phase-shift, using the circuit shown in Fig. 34. When the Electronic Switch and scope controls are properly adjusted, the pattern should appear somewhat as shown in Fig. 35.

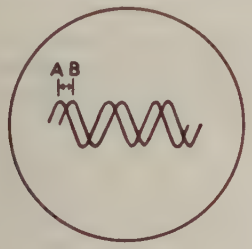


Figure 35

The phase difference between the signals applied to the "A" and "B" inputs of the Electronic Switch may be approximated by comparison of the signal peaks on the scope image. The phase difference is approximated by the relative positions of the peaks, taking the spacing for an entire cycle across the screen of the scope into account, and remembering that there are 360° in a complete sine-wave cycle.

Thus, if the distance between peaks (A-B, Fig. 35) is one-tenth the distance for a complete sine-wave cycle, the phase difference between the two signals is $^1/_{10}$ of 360° or 36°.

Although this technique is valuable for approximating phase differences, it is not good for determining small phase differences because of the difficulty in accurately measuring the distance between sine-wave peaks.

PHASE MEASUREMENT

When two sinusoidal voltages of the same frequency are applied to an oscilloscope, one to each set of deflection plates, the figure on the screen is either a straight line, a circle, or an ellipse. If the two voltages are not derived from the same source, the figure moves; if they are, it stands still.

Fig. 23 shows a general circuit for measuring phase. The circuit in the block can be an amplifier stage, an R-C network, a whole amplifier, etc. Phase shift is practically always associated with any deviation from flat frequency response—always in ordinary circuits. In nearly all cases phase shift can be detectable before the drop in frequency response can be measured.

If the input and output of the test circuit are exactly in phase, the oscilloscope display will be an inclined straight line, similar to Trace No. 14. The direction of inclination will depend on whether or not phase inversion occurs in the test circuit.

The formation of an ellipse may be demonstrated by using the circuit shown in Fig. 23. As the 250K pot. is adjusted the shape of the ellipse will vary, demonstrating that the shape depends on the relative phase difference between signals fed to the horizontal and vertical inputs of the scope.

If the two signals are exactly 180° out-of-phase, a diagonal slanting line is still obtained, but the slant is in the opposite direction. (Fig. 36-7).

A phase difference of exactly 90° will result in an almost perfect circle (Fig. 36-4) provided the HOR. and VERT. GAIN controls are adjusted for equal deflection. If there is more gain vertically, the circle will become a vertically elongated ellipse. More gain will result in a horizontally elongated ellipse.

A phase difference of less than 90° will result in an ellipse, the long axis of which is at an angle, as shown in Fig. 36-2. The ellipse will slant in the opposite direction if the phase difference is between 90° and 180°.

To measure the phase angle, take the following steps: (1) disconnect the vertical input and adjust the horizontal gain to a value that gives a line on the screen of convenient length; (2) disconnect the horizontal input and adjust the vertical gain to give a vertical line of the same length; (3) reconnect the horizontal gain and measure the length of each axis a and b of the elliptical figure. The phase angle is given by the formula. (See Figure 37 and 21-1)

$$\frac{b}{a} = \tan \tfrac{1}{2} \Phi$$

Figure 36

A table is appended. If the phase angle is 90°, the display will be a circle. For phase angles greater than 90°, the circle thins down into an ellipse again, but with its major (longer) axis inclined the other way. (See Figure 37)

PHASE ANGLE TABLE

Phase angle Φ	Ellipse axis ratio $\frac{a}{b}$ $(= \tan \frac{\Phi}{2})$
Φ	Φ
5°	.044
10°	.087
15°	.132
20°	.176
30°	.268
40°	.367
50°	.466
60°	.577
70°	.700
80°	.839
90°	1.

Figure 37

Since a slope in gain or transmission loss is nearly always associated with phase shift, it is necessary to readjust the vertical gain to give equal vertical and horizontal deflections on the screen, whenever the frequency is changed.

Of the two methods for measuring phase shift, the first (using an electronic switch) is generally used for demonstration purposes, and the second (the ellipse method) for practical laboratory work. As experience is gained in using the second method, many technicians acquire the ability to estimate the phase difference from the general shape of the ellipse, without taking time to actually measure "a" and "b", or to perform the necessary calculations.

DIGITAL PULSE MEASUREMENTS

The WO-527A Oscilloscope is an ideal instrument for analyzing digital pulse waveforms.

In order to perform and understand digital pulse measurements, ten factors should be considered:

1. DC Voltage Level
2. Shape/Symetry
3. Amplitude
4. Period or Time-Interval/ Frequency
5. Repetition Rate (PPS)
6. Rise-Time
7. Fall-Time
8. Pulse Width
9. Duty Cycle
10. Polarity

Two common sources of pulses found in Digital Equipment are:

1. Transistor-Transistor Logic. Referred to as T^2L or TTL Typical operating voltages are from 0.4 VDC to 5.0 VDC and
2. Cosmos/Cmos which have typical operating voltages of: VDD = 5 to 15 VDC

To analyze pulses derived from these sources: Position the vertical amplifier vertical volts/division to "1 volt". Position the vertical CAL control of the WO-527A control fully clockwise. Use the VIZ WG 478 Universal Probe in the direct configuration for TTL circuitry and for Cosmos/Cmos the X10 LoCap configuration to minimize loading.

NOTE: While in the X10 LoCap Mode, you must reduce the attenuation within the vertical amplifier by setting Vertical Volt/Division control knob to ".1 volt".

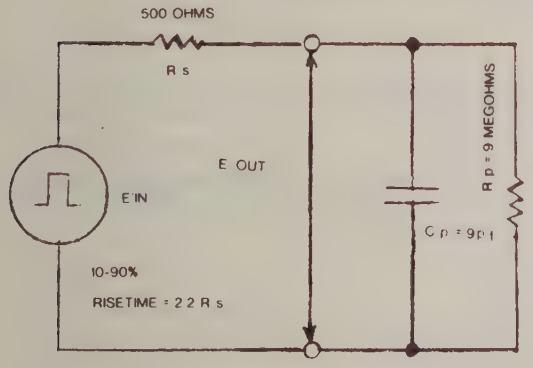


Figure 39
Example: Pulse circuit for rise-time analysis.

TROUBLESHOOTING

When measuring pulses, it is essential to have the specifications of the piece of equipment being tested as a reference so that a meaningful interpretation of the ten bits of information as listed above can be made.

Figure 38. Illustrated here is a typical pulse train along with information useful in troubleshooting a piece of digital equipment using the VIZ WO-527A oscilloscope.

D. C. PULSE MEASUREMENTS

A diagram of a generalized pulse circuit is shown in Figure 39. R_s represents the source resistance at the point of measurement. To connect a cable directly from that point to the oscilloscope would add excessive capacitance to the input (approximately 100pf/m). So the normal approach is to use a resistance probe which has a 9 megohm resistance in parallel with approximately a 9 pf. (Picofarads) capacitance. The input impedance of the WO-527A is 1 megohm shunted by 30 pf. The overall effective input impedance of the probe (while in the 10X Lo-Cap configuration) is approximately 10 megohms of resistance in parallel with 6.92 pf. (Picofarads) of capacitance. However, the decrease of capacitance is bought at the expense of an increase of attenuation by a factor of 10. In the diagram, Cp represents probe capacitance taken as 9 pf. in our example. Re and Cp form an integration circuit with a rise-time of 2.2 n Sec.

If Rs is equal to 500 ohms, the rise-time becomes:

$$2.2 \times 500 \times 9 \times 9^{-12} = .891^{-8} \text{ or } 8.91 \times 10^{-9} = 8.91 \text{ n sec. (nanoseconds)}$$

The rise-time of the probe/oscilloscope *combination* is sometimes stated within the specifications. The figure is usually taken with a source impedance of 25 ohms, in which case the capacitive loading effect can be disregarded. In practical measurements however, this is not always the case; so square-law addition has to be used to include the error.

$$T \text{ observed} = [(T \text{ probe} - \text{oscilloscope})^2 + (T2.2 \text{ Rs Cp})^2 + (T \text{ signal})^2]^{1/2}$$

Another problem occurs in measuring delay between pulses originating from different source impedances, capacitive loading results in different increases of rise-time. As delay is measured at 50% pulse amplitude, half the difference of increase may be interpreted erroneously as delay.

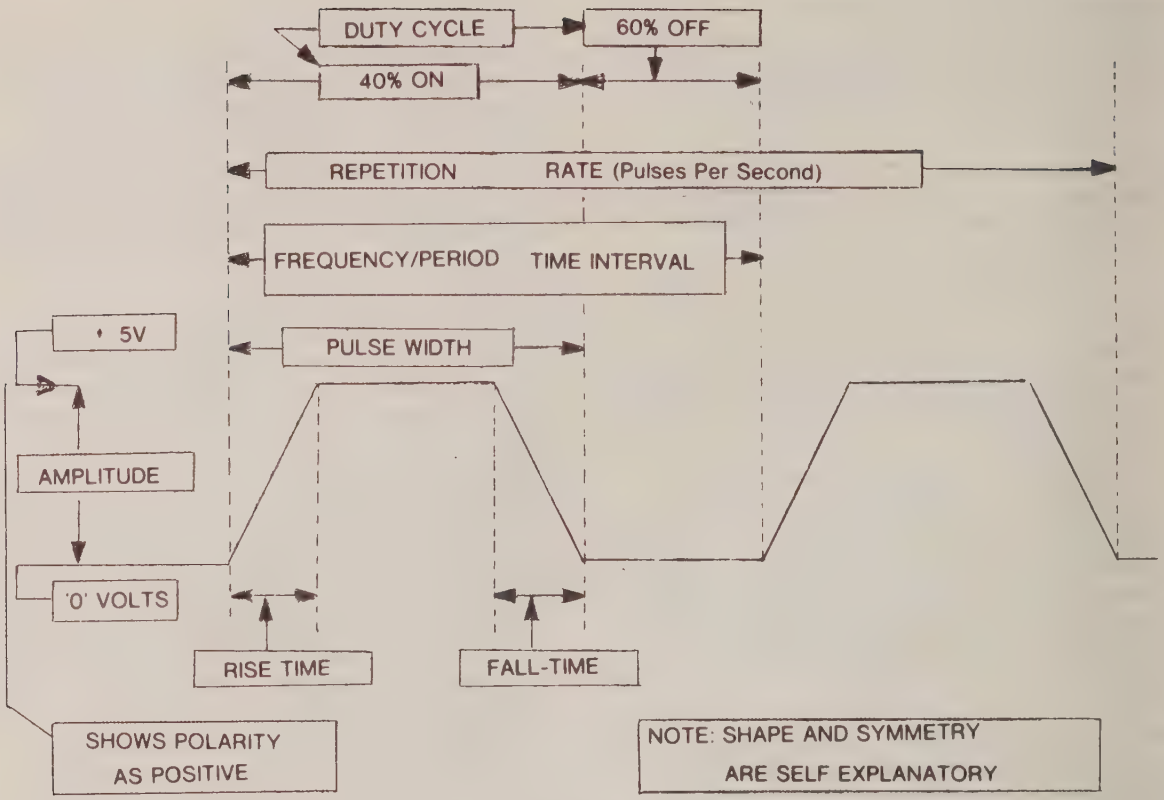


Figure 38
Typical pulse train with useful information for trouble shooting digital equipment.

A good way to become familiar with DC pulse measurements is to build up a couple of integration networks with different values so that you can see the differences in time-constants as displayed on the VIZ WO-527A Oscilloscope.

A very good source of DC pulses can be found using the VIZ WR-549A Pulse Generator. This generator has a 5 Hz to 5 MHz. frequency range and the pulse width can be varied from 100 n sec to 0.1 seconds with an unlimited duty cycle.

The VIZ WR-549A Pulse Generator can also be a very valuable tool as a troubleshooting aid in DC or digital circuit analyzation.

THEORY OF OPERATION

LOW VOLTAGE POWER SUPPLY

Power transformer T1 contains a dual primary, connected either in parallel for 120 volt operation, or in series for 220 volt operation. This selection is accomplished by switch S1. Power from the AC line goes to fuse F1 and then through the PWR ON switch to Switch S1.

There are five secondary windings on the power transformer. One of these is a high voltage winding and will be discussed later. The remaining four windings make up the low voltage power supply. The first of these is a 6.3 volt winding that supplies heater current to the CRT. Another winding is connected to a full wave bridge rectifier which is comprised of diodes CR5 thru 8. The output of this bridge is filtered by C1A and C1B. The voltage at this point is about 210 volts DC. Resistor R5 reduces this voltage to 180 volts DC. The 180 volt supply is filtered by C1C. The next winding is center-tapped. This center-tap is grounded and the two ends of the winding are connected to bridge rectifier CR-103 located on the vertical amplifier circuit board. CR-103 produces both plus and minus voltage with respect to ground. C-134 filters the plus voltage while C-135 filters the minus voltage.

Integrated circuit U103 is a dual polarity regulator. It provides base bias for Q104 and Q105 series pass transistors. Regulation is accomplished by sensing the current through R166 and R168 which also serve as current limiting resistors. The voltage drop developed across these two resistors is used by U103 to vary base bias to Q104 and Q105 and in so doing, regulate the output. Control R163 is adjusted to give an output of +15 volts and −15 volts. C130 and C131 reduce load transients.

The last winding on the transformer is connected from ground to R6. The AC signal from R6 is connected to the horizontal board and is used for line synchronization.

HIGH VOLTAGE POWER SUPPLY

The high voltage winding of the power transformer is connected to points 1 and 2 on the high voltage circuit board. CR301, CR302, C301 and C302 form a voltage doubler that provides an output of about 2100 volts DC. This DC voltage is negative with respect to ground. The voltages required by the CRT grids and cathode are obtained from what is basically a resistance divider. The current in this divider is fed into integrated circuit U301. U301 contains a current mirror pair which is used for high voltage regulation. The output of this IC drives three high voltage NPN transistors. Three transistors are used in order to give a high breakdown voltage. The current through these transistors, which is determined by U301 and its associated components, establish the magnitude of the high voltage. This circuit provides excellent high voltage regulation.

CALIBRATOR

Integrated circuit U302 and its associated components form a square wave oscillator. The frequency is fixed at approximately 1000 Hz. Resistors R349, R350, and R351 are precision resistors which are arranged to insure an output level of .4 volts. The output is taken from the junction of R350 and R351 and connected to the jack on the front panel.

VERTICAL INPUT AND ATTENUATOR

A signal applied to the vertical input connector is coupled directly to switch S103 ("DC" "GND" "AC"). In the "AC" position the signal is coupled through C136 to the input attenuator. This permits an AC signal superimposed on a DC potential to be seen without the DC component being displayed. In the "DC" position the signal is coupled directly to the attenuator. In the "GND" position the input signal is coupled through C136 and R101 to ground, and at the same time the input to the attenuator is grounded.

The function of the input attenuator is to reduce the input signal by a known factor, and also to apply that signal, undistorted, to the vertical preamp. At DC and low AC frequencies resistance dividers attenuate the signal; at higher frequencies this is accomplished by resistor-capacitor networks. Capacitors C102, C105, C108, C111, and C113 are adjusted during calibration to equalize the input capacitance of the oscilloscope on all positions of the volts/CM switch when using the VIZ WG-478 attenuation probe.

Vertical attenuator switch S104 is a four pole eleven position switch. Its function is to switch into the circuit the proper divider networks each having its own attenuation factor.

In addition to these networks it is also possible to by-pass the attenuators resulting in a "divide by one" situation. It should be noted that many possible over-all attenuation factors are available, and that the input attenuator termination R123 has been taken into consideration when determining the attenuation factor.

To illustrate exactly what the attenuator does under various input voltages and switch positions refer to the chart that follows.

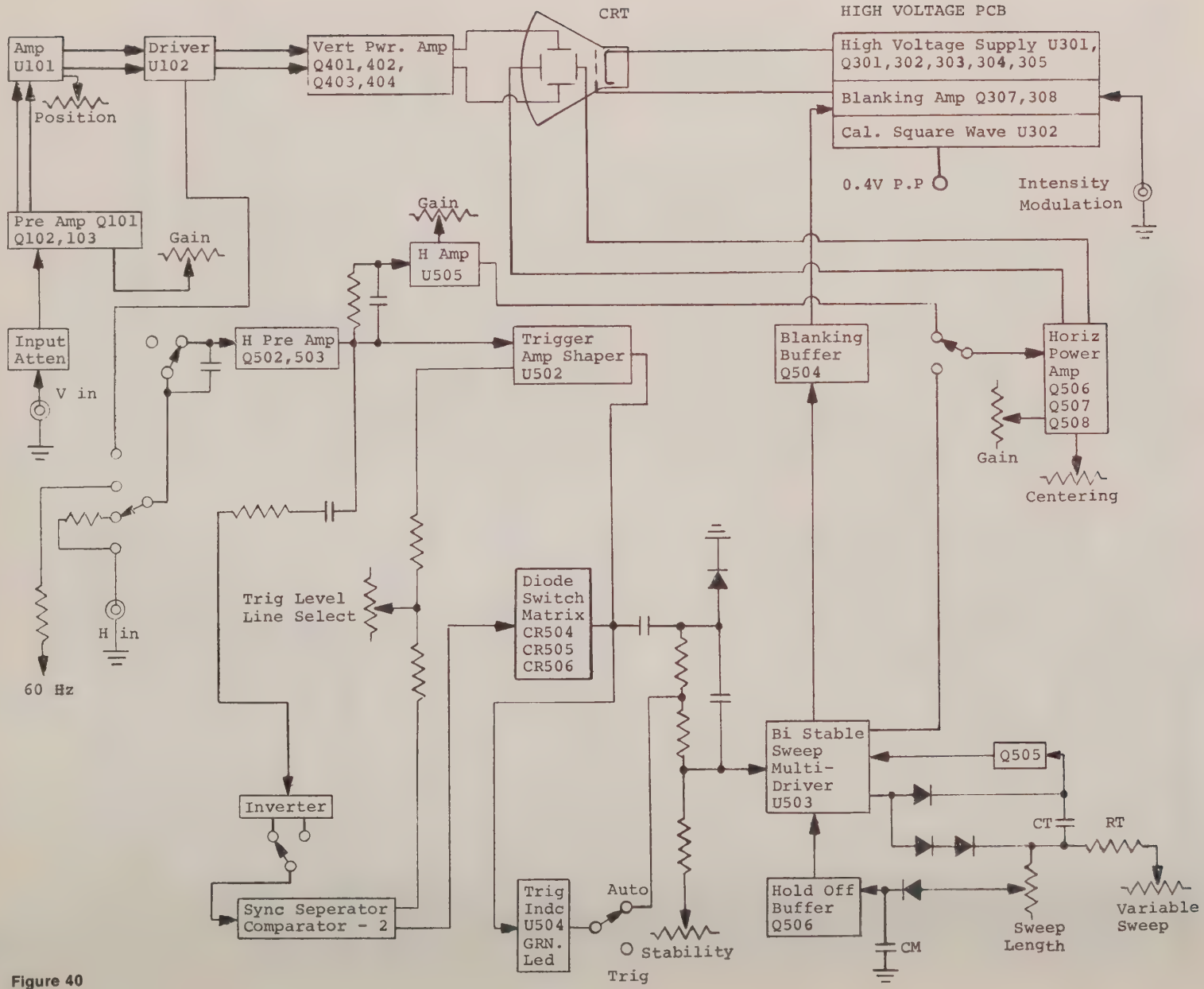

CRT
HIGH VOLTAGE PCB
Amp U101
Driver U102
Vert Pwr. Amp Q401,402, Q403,404
High Voltage Supply U301, Q301,302,303,304,305
Blanking Amp Q307,308
Cal. Square Wave U302
Position
0.4V P.P
Intensity Modulation
Pre Amp Q101 Q102,103
Gain
H Amp U505
Input Atten
V in
H Pre Amp Q502,503
Trigger Amp Shaper U502
Blanking Buffer Q504
Horiz Power Amp Q506 Q507 Q508
Gain
Centering
Trig Level Line Select
Diode Switch Matrix CR504 CR505 CR506
H in
60 Hz
Bi Stable Sweep Multi-Driver U503
Q505
Inverter
CT
RT
Trig Indc U504 GRN. Led
Auto
Hold Off Buffer Q506
Variable Sweep
Sweep Length
Sync Seperator Comparator - 2
Stability
Trig
CM

Figure 40

Voltage Applied	Volts/CM Switch Position	Attentuator Networks Active	Over-All Attentuation Factor	Volts Across Termination (R-123)
20	20	÷1000÷2	÷2000	.01
10	10	÷1000	÷1000	.01
5	5	÷ 100÷5	÷ 500	.01
2	2	÷ 100÷2	÷ 200	.01
1	1	÷ 100	÷ 100	.01
.5	.5	÷ 10÷5	÷ 50	.01
.2	.2	÷ 10÷2	÷ 20	.01
.1	.1	÷ 10	÷ 10	.01
.05	50 mv	÷ 5	÷ 5	.01
.02	20 mv	÷ 2	÷ 2	.01
.01	10 mv	NONE	÷ 1	.01

VERTICAL PRE-AMPLIFIER

The vertical preamp consists of two FET transistors Q101 and Q102, and their constant current source Q103. It also contains a DC balance circuit, and a variable gain control.

Q101 and Q102 form a differential amplifier and provide a double-ended output from a single input signal. Since the current supplied to these two transistors is constant, an increase of current in one will cause a corresponding decrease in the other. This difference signal is amplified in the following stages to drive the vertical deflection plates of the CRT.

A DC voltage is developed across CR101 and CR102. This voltage goes from +.6 to −.6 volts. R115 which is across CR101 and CR102 is adjusted so that the static source voltage of both Q101 and Q102 are the same. This balances the circuit. B+ voltage for Q101 and Q102 are the same. This balances the circuit. B+ voltage for Q101 and Q102 is supplied from +15 volts through R127 and control R162. This control is adjusted to balance the drains of Q101 and Q102 when the vertical position pot, R3 and R4, is in the center of its rotation. This is done to center the trace vertically on the CRT. An impedance, comprised of R161 and R169, is connected between the two sources of Q101 and Q102. Both R161 and R169 are variable controls which control the gain of the first stage. R161 is an internal adjustment and is used to calibrate the over-all vertical amplifier. R169 is a variable gain control on the front panel.

VERTICAL AMPLIFIER

Integrated circuit U101 contains five discrete NPN transistors. Two of these are used as buffers, two as amplifiers, and one as a constant current source. The differential signal from the pre-amp is coupled directly to the base of two transistors which serve as differential emitter followers. They also act as buffers between the amplifiers. Bias for these two transistors comes from the ganged vertical position control. At the center of rotation both transistors have the same bias potential. As the vertical position control is adjusted this bias changes an equal, but opposite amount, on the two transistors.

The differential signal from the emitters is coupled directly to the bases of two transistors. These two form a differential amplifier, and share a constant current source. As before, an increase of current in one transistor causes a decrease of an equal amount in the other. The differential signal is taken from the collectors and coupled to integrated circuit U102. U102 provides another buffer stage which is made up of a differential emitter follower. The signal from the two emitters is connected to the vertical output board through 300 ohm twin-lead. A sample of the signal from both emitters is also fed to a pair of transistors which act as an amplifier and inverter. The signal then drives an emitter follower. It is this signal which is used for internal triggering.

VERTICAL OUTPUT AND POWER AMPLIFIER

The differential signal is coupled to Q403 and Q404. These transistors are in series with the emitters of Q401 and Q402 which are the final power amplifiers of the vertical amplifier. Q403 and Q404 control the current of the output pair. The differential signal is taken from the collectors of Q401 and Q402 and coupled to the CRT through a pair of resistor-inductor networks. R412 and C404 are adjusted during calibration to obtain maximum frequency response and flatness of the vertical amplifier.

CRT CONTROL

A high DC voltage of about -1900 volts is generated on the high voltage circuit board and is connected directly to the cathode of the CRT. One side of the CRT heater element is also connected to the cathode. This prevents a high voltage arc-over between the heater and cathode in the tube. A DC voltage of about -1950 volts is connected to the control grid. This voltage will vary depending on the intensity control setting; the brighter the trace

on the CRT, the more positive the voltage on the control grid. In normal operation of the Oscilloscope, the trace must be blanked (turned off) during re-trace. This is accomplished by the blanking circuit on the high voltage circuit board.

A signal from the horizontal circuit board (present during re-trace) is coupled through R 328 and CR 313 to the base of Q 308. The signal is amplified, inverted, and coupled through R 340 and CR 311 to the base of Q307. When the trace is not blanked the collector of Q307 is high at about 70 volts DC. This is due to the clamping action of R 338 and zener diode CR 308. When the trace is blanked, the collector of Q307 goes low. The transition from 70 volts to 0 volts is coupled through R 325, R 326, and R 353 to the grid of the CRT. This reduces the voltage on the control from -1950 to -2020 volts. The additional negative voltage cuts off the beam in the CRT.

Focus voltage is obtained from the resistance divider mentioned under high voltage.

Beam deflection is covered under vertical output and horizontal output.

SWEEP GENERATOR

The trigger signal from C-521 is coupled through C-531 to integrated circuit U-503. U-503 contains a Bi-Stable Multi Vibrator, which is activated by the trigger signal. This causes pin 1 of U-503 to go high. Pin 1 is connected directly to the base of Q-504 and therefore turns on Q-504. The signal from the emitter of Q-504 is coupled to the high voltage board, and un-blanks the trace.

The signal from Pin 1 of U-503 is also coupled through R-585 to Pin 12 of U-503. This causes Pin 14 to go from 1 volt down to 0 volts. This signal is coupled to Q-505 which acts as a buffer and also turns on the two more transistors contained in U-503. The output from Pin 10 of U-503 is used to charge up a timing capacitor (CT). The value of CT along with a resistor (RT) that is in series with it determines the rate that CT will charge.

The output from Pin 10 is also fed to the sweep length control R-590. This control determines the point at which Q-506 turns on. The signal is taken from the source of Q-506 and coupled to the junction of R-580 and R-581, through R-581, to the Bi-Stable Multi Vibrator of U-503. U-503 returns the sweep signal to its original state. This complete process generates a sawtooth wave form at PIN 10 OF U-503 and it is fed through the horizontal amplifier to the deflection plates of the CRT.

During retrace, transistor Q 506 remains turned on. This causes diode CR 514 to be forward biased, which in turn prevents any trigger pulses from C 521 from triggering the sweep generator. An additional time delay due to capacitor (CTT) continues to prevent triggering for a short time. This allows U-503 and its associated circuits to fully stabilize before the next trace begins.

HORIZONTAL-TRIGGER, TIME BASE AND SWEEP TV V, TV H AND TV LINE

TRIGGER AMPLIFIER

The Trigger Signal is obtained from one of four sources (push buttons) in the TRIG SOURCE group on the front panel. In the "INT" mode a sample of the vertical amplifier signal is used. When "LINE" trigger is selected, a winding on the power transformer supplies the signal. In the "EXT" mode, a signal applied to the external trigger BNC on the front panel supplies the signal. "EXT ÷ 10" attenuates the signal by a factor of ten.

Once the proper source has been selected, it is coupled through R551 and C523, and then through R536 to Q502. This provides AC coupling of the trigger signal. If DC coupling of the trigger signal is desired, switch "IN/DC", "OUT/AC" (S507) is depressed which places a short across R551 and C523.

Q502 acts as source follower, and Q503 acts as a current source for Q502. The signal present at the source of Q502 is fed into pin 4 of integrated circuit U502. U502 is an NPN array containing five transistors. When the oscilloscope is being used in the "NORM" display mode, +15 volts is connected, through a portion of the "NORM" switch, to R563 and then to pin 12 of U502. This turns on a current source in U502 which turns on one of two more transistors. One transistor conducts during positive going signals while the other conducts during negative going signals. Two more transistors serve as buffers. The signal is then coupled through CR512 for positive triggering, or CR513 for negative triggering. When triggering on the positive going signal the cathode of CR512 is connected through R562 and then switched by S513 to −15 volts. During positive triggering the cathode of CR513 is tied to +15 volts through R550; this prevents negative signals from triggering. During negative triggering the cathode of CR513 is connected through R549 and then switched by S513 to −15 volts. The cathode of CR512 is tied to +15 volts through R562 to prevent positive triggering. The trigger signal is coupled through C520 for positive, and C522 for negative. Both of these are connected to C521.

TV V, TV H, AND TV LINE

When the oscilloscope is being used in either "TV V", "TV H" or "TV LINE", the current source of U502 is turned off. This prevents the signal from going through the normal trigger amplifier, which when viewing composite video, would cause an unstable trigger signal. In-

stead, the signal is coupled to buffer/inverter Q501. Both the drain and the source of Q501 are connected to a portion of the slope switch. The signal is taken from the drain if the incoming waveform contains negative going sync pulses. For positive going sync pulses the signal is obtained from the source. The signal is then coupled to integrated circuit U501. U501 and its associated circuitry separate the horizontal and vertical sync pulses, and also strips out the video signal. In addition to this, U501 also blocks out every other pulse. This results in what is basically a "divide by two" situation as far as the triggering of the sweep is concerned. This allows two complete frames, or lines, to be displayed on the CRT when used in conjunction with the pre-set "TV V", and "TV H", sweep selector.

In the "TV LINE" mode vertical sync pulses are used to trigger the sweep. The only difference between "TV V" and"TV LINE" is that the trigger signal can be varied with respect to time in the "TV LINE" mode. This is accomplished by a comparator circuit that feeds back a portion of the vertical sync pulse signal and in doing so, generates a ramp voltage.

The "TV LINE" select control determines the length of the ramp, and therefore, the point at which the sweep is triggered. This allows one complete frame of video to be displayed, one line at a time if desired, when the proper sweep speed is selected.

A diode switch matrix comprised of CR504, CR505, and CR506, is used to couple either "TV V", "TV H", or "TV LINE", trigger signals to C515. This allows these signals to be switched without actually going through a front panel push button switch, thus reducing the possibility of noise pick-up.

HORIZONTAL AMPLIFIER

The Horizontal Drive Signal from S512 is fed through horizontal calibrate control R 608 and then to integrated circuit U506. U506 contains five NPN transistors. One of these is used as a current source for the first pair of differential amplifiers.

The horizontal position controls R1 and R2 set the bias at pin 16 of U506, which is the base of one of the transistors. As the voltage on the other base is increased, the current increases and causes a decrease of current in the other transistor, because both transistors share the same current source, and the voltage on pin 16 is constant. The differential signal between pins 1 and 2 of U506 is connected directly to pins 6 and 13 of U506, and is amplified to a level suitable to drive horizontal output transistors Q507 and Q508. The signal from the collectors of these two transistors is connected directly to the horizontal deflection plates of the CRT.

MAINTENANCE

General

Caution: Do not strike or apply excess pressure to the cathode-ray tube as breaking the tube (impulsion) may result in injury from flying glass. Safety goggles should be worn at all times when handling the cathode ray tube.*When the case of the instrument is removed, high voltages are exposed and the safety precautions outlined in the front of this manual should be observed.*

This manual includes a schematic diagram and a block diagram of the circuit along with a circuit description. Note that all components on the vertical preamplifier have symbol numbers in the 100 series. The plus and minus 15 volt power supply is located on the rear of this circuit board. Components on the high voltage board have symbol numbers in the 300 series. Components on the Vertical Power Board have symbol numbers in the 400 series. Components on the Horizontal Board have symbol numbers in the 500 and 600 series. Note: components on the sweep switch and all other components are on the series 1 thru 99. The 200 series are not used. If the Oscilloscope does not operate properly, conventional trouble-shooting techniques should be used including resistance and voltage checks. The Transistors can be checked using an in-circuit transistor tester, such as the VIZ WT-501A. For a meaningful test of diodes, however, it is recommended that one lead be disconnected so that an out-of-circuit test can be made. Internal adjustments should be made with a line voltage at 120 volts 60 Hz. *(Note—extreme care is to be taken when repairing or aligning this equipment when energized as voltages as high as 2000V may be present throughout.)* Before making any adjustment, allow at least ten minutes warm up.

REMOVING COVER

To remove the top and bottom cover from the WO-527A, remove the screws holding the covers on the instrument. (It is not necessary to remove the combination handle and tilt stand from the top cover). Adequate access to both the component and foil side of the circuit board is now available. If necessary, the cathode ray tube and magnetic shield can be removed as described below.

REMOVING CATHODE-RAY TUBE

The CRT can be removed as follows: Remove all knobs on the front panel. (Note some have set screws holding knobs to shafts). Unsolder the wire connected to the 0.4V P-P gray jack on the front panel. Remove the 4 nuts and 1 ground nut holding the front plastic bezel to the frame. Remove the special nut located on the upper left corner of the front panel. Remove front panel. *CAUTION:* The LED indicator assembly is part of the panel and care should be taken to avoid pulling on this harness. There is enough slack in the harness to enable you to lay the panel aside. Remove the tube socket and loosen the clamp screw around the neck of the tube. The CRT can now be removed by gently pulling the tube out through the front. If the magnetic shield is to be removed, remove the 3 sheet metal screws holding the shield to the front of the frame. *CAUTION:* Do not drop or distort this shield as this may seriously damage its magnetic shielding characteristics. To install a new tube, follow the above procedure in reverse. Do not tighten tube clamp on neck of the tube until you have rotated the tube for a horizontal trace. Follow HIGH VOLTAGE, INTENSITY, AND ASTIGMATISM alignment procedure after installation of a new CRT.

INTERNAL ADJUSTMENTS

Test equipment required for the various adjustments:

VTVM with P-P scales, such as VIZ WV-98C, WV-500B, WV-510A, or WV-534A Voltohmysts.

HORIZONTAL

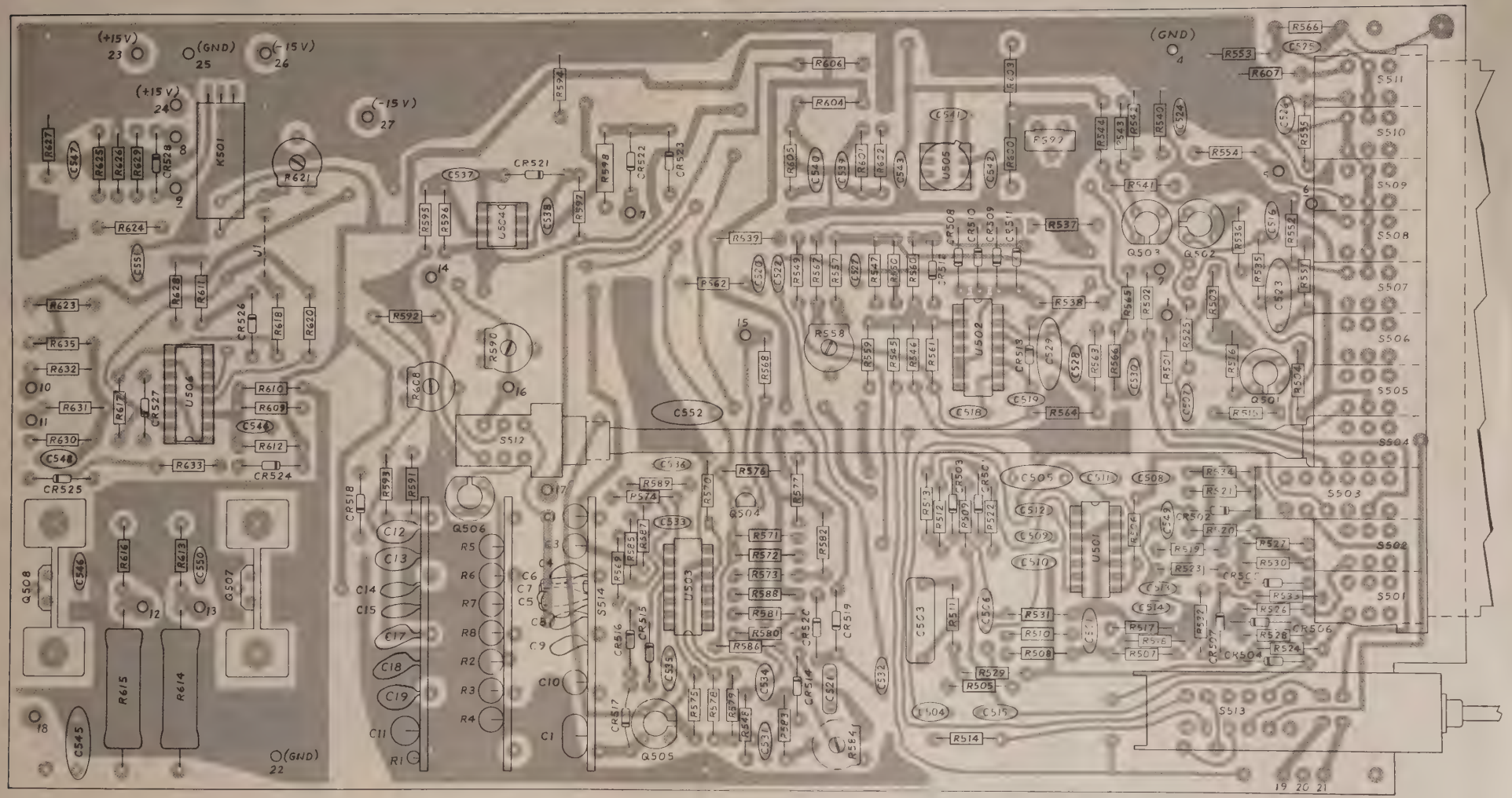
The horizontal circuit board is factory adjusted and sweep calibration should not be attempted as an accurate scope calibrator is required. It is suggested that if sweep calibration is required, the scope be sent to a VIZ Repair Station. The following is a list and function of controls on the horizontal board:

R599	Balance
R590	Sweep Length (adjust for full sweep)
R558	Trigger control (adjust for center range of the green LED)
R584	Trigger stability
R608	X1 Sweep (Scope calibrator required)
R621	X10 Sweep (Scope calibrator required)

LOW VOLTAGE POWER SUPPLY ADJUSTMENT

Voltage adjust pot (R163) on the vertical circuit board adjusts the Low Voltage Power Supply for ±15 volts. Connect the test lead of a Voltmeter to terminal #5 and connect the black lead to ground. Adjust R163 for +15 volts. This adjustment sets both +15V and −15V.

Figure 41 shows the location of parts on the horizontal printed circuit board, figure 42 the vertical amplifier circuit board, figure 43 the high voltage circuit board, and figure 44 the vertical deflection board.


(+15V)
23
(GND)
25
(-15V)
26
(+15V)
24
(-15V)
27
(GND)
4
K501
R621
R627
C547
R625
R626
R629
CR528
8
2
R624
C551
J1
R623
R628
R611
CR526
R618
R620
R635
R632
10
R631
11
R630
C548
CR525
R633
R610
R609
C549
R612
CR524
U506
R617
CR527
R616
R613
C550
Q508
Q507
12
13
R615
R614
C546
C545
18
(GND)
22
CR518
R593
R591
C12
C13
C14
C15
C17
C18
C19
C11
R1
Q506
R5
R6
R7
R8
R2
R3
R4
C6
C7
C5
C8
C9
C10
C1
S514
R594
R606
R604
C541
R597
R598
R602
CR522
CR523
C537
CR521
R595
R596
U504
C538
R592
14
R590
16
R608
S512
C552
17
C536
R589
R574
C533
R576
R577
Q504
R571
R572
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R588
R581
R580
R586
R582
R585
R587
R584
U503
CR515
CR516
CR517
C535
R575
R578
R579
R583
C534
C531
C532
CR514
C521
C532
Q505
R584
R568
15
R558
R559
R545
R546
R561
C518
C519
R564
U502
R562
C520
C522
R549
R547
R557
R550
C527
R560
R540
CR508
CR510
CR509
CR511
R539
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C528
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R502
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U501
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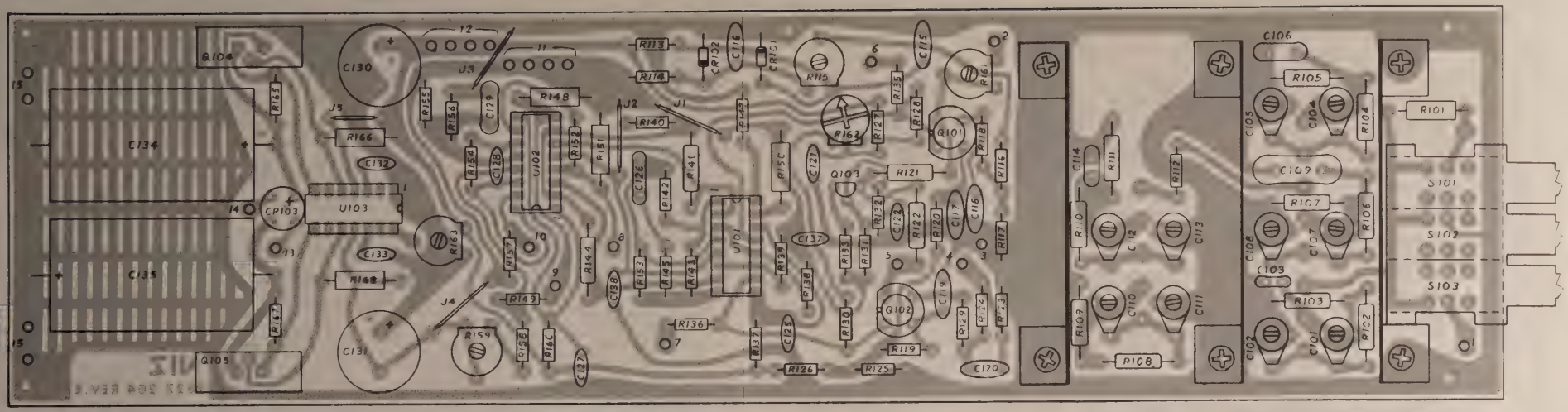
R504
R574
R521
R520
CR502
R527
R530
R523
R533
R526
R519
R528
CR506
CR504
R524
R531
R510
R508
R529
R505
R514
C504
C515
R511
R513
R512
R509
R522
C506
C507
C514
R517
R516
R507
R532
CR507
S513
19
20
21

Figure 41

Figure 42



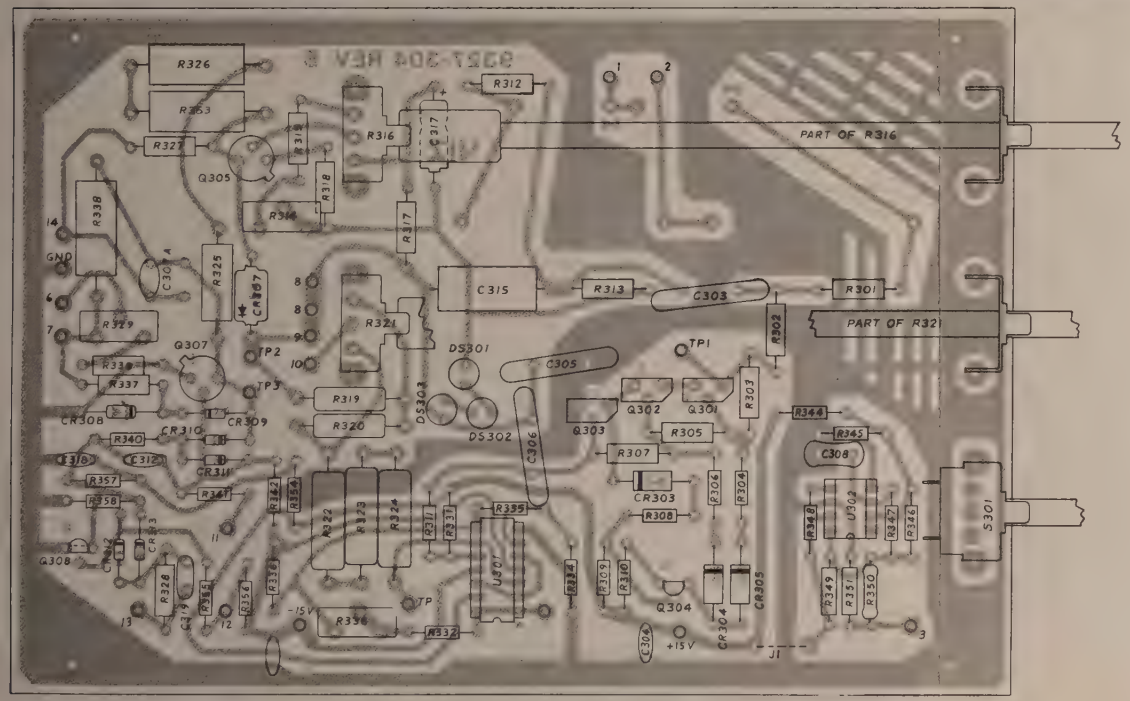


Figure 43

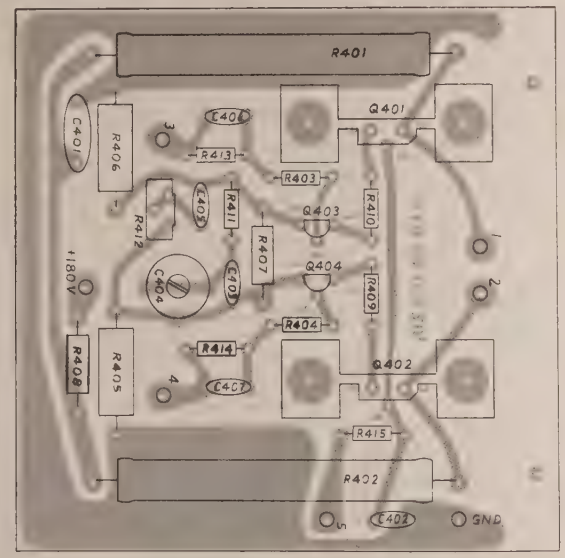


Figure 44

REPLACING Q101 & Q102 VERTICAL AMPLIFIER

If Q101 & 102 (matched pair) are replaced, the following adjustment procedure should be followed. No test equipment is required. Set scope controls as follows:

INTENSITY	—fully clockwise
FOCUS	—mid-range
HORIZONTAL POSITION	—mid-range
VERTICAL POSITION	—mid-range
VERT-IN	—"GND"
VERTICAL VOLTS/DIVISION	—".1 volts"
DISPLAY	—"NORM"
TRIG SOURCE	—"INT"
(Vertical) CAL	—CCW

Make sure VERTICAL POSITION is mid-range; index mark straight up. Install Q101 & 102 in proper transistor sockets. Turn power on and allow for warm-up. Adjust R162 (on Vertical Circuit Board) to center the trace. As you slowly rotate the front panel vertical CAL knob, adjust DC balance pot R115 (near R162) for minimum trace movement. The most effective way to perform this adjustment is to continue rotating vertical CAL knob on the front panel from a full CC to CCW while adjusting R115 for minmum vertical trace movement. It will be necessary to readjust R162 to bring the trace back to center. When R162 & R115 are properly adjusted, rotating the vertical CAL knob will cause little or no vertical movement of the trace. If R162 will not balance the trace, then reverse Q101 & 102 and repeat the above procedures.

VERTICAL GAIN ADJUSTMENT

Vertical gain is factory calibrated and should only be re-calibrated if Q101 & Q102 are replaced

Set scope controls as follows:

INTENSITY	—fully clockwise
FOCUS	—mid-range
HORIZONTAL POSITION	—mid-range
VERTICAL POSITION	—mid-range
VERT-IN	—"DC"
VERTICAL VOLTS/DIVISION	—".1 volts"
DISPLAY	—"NORM"
TRIG SOURCE	—"INT"
SWEEP TIME/DIVISION	—".5 m sec."
(vertical) CAL	—full clockwise

Connect a jumper wire from the 0.4V P-P Jack to the VERT IN BNC connector. This now places 0.4V peak to peak square wave of approximately 1000hz to the vertical amplifier. Adjust TRIG TV LINE SELECT knob until green LED is on, either + or − push selection can be used. Adjust R161 on vertical circuit board for 4 centimeters (cm) (each major division is 1 cm). This completes vertical gain calibration for the WO-527A.

HIGH VOLTAGE, INTENSITY RANGE, ASTIGMATISM ADJUSTMENTS

CAUTION: When making adjustments on the high voltage board, use an insulated adjusting tool since up to 2000V may appear at various points in the instrument. Set scope controls as follows:

INTENSITY	—fully clockwise
FOCUS	—mid range
HORIZONTAL POSITION	—to obtain full trace
VERTICAL POSITION	—mid-range
VERT-IN	—"GND"
VERTICAL VOLTS/DIVISION	—".1 volts"
DISPLAY	—"NORM"
TRIG SOURCE	—"INT"
SWEEP TIME/DIVISION	—"5. M Sec."
IN TRIG/OUT AUTO	—IN

A meter capable of measuring up to 2000V is required for this procedure such as VIZ WV-38A or WV-98C, WV-500B, WV-510A instruments with a high voltage probe WG-411A and appropriate multiplier resistor. Make sure ground lead of meter is conncted to scope ground before applying meter test leads to high voltage.

Connect the hot test lead of your meter to "TP2" on the high voltage board. Adjust "Hi Volt" pot (R338) to-1850 volts. Turn front panel INTENSITY full CW. Adjust "Int Lim" pot (R314) on circuit board until a dot appears; then back off slightly until the dot disappears. Re-adjust "Hi Volt" pot for −1850 volts. Turn front panel INTENSITY CC to CCW observing −1850 volts. This voltage should remain constant. Adjust FOCUS control on front panel to mid-range then adjust "ASTG" Pot (R329) on High Voltage circuit board for smallest dot possible. This completes adjustment of the High Voltage.

Replacement Part Policy

It is VIZ's policy to make replacement parts available to its customers at the least cost and as quickly as possible. All items where a part number is listed in BOLD FACE are available from your local VIZ Distributor. Please use the VIZ part number when ordering:

All other items are standard parts available at most Electronic Distributors. Please order these parts by the description as listed, from your distributor.

REPLACEMENT PARTS LIST
WO-527A

Symbol	Description	Stock No.
	Capacitors	
C1	**Mylar, 1 MFD, 250V**	**9327-157**
C2	**Mylar, .1 MFD, 250V**	**9327-161**
C3	**Mylar, .01 MFD, 250V**	**9327-162**
C4	**Mica, 1000 pf, 100V**	**9327-167**
C5	Mica, 82 pf, 50V	9327-168
C6, 7	**Variable, 2.3-20 pf**	**9327-169**
C8	Mica, 24 pf, 50V	9327-171
C9	Mica, 1200 pf, 1000V	9327-235
C10	**Mylar, .1 MFD, 250V**	**9327-161**
C11	Mylar, .47 MFD, 250V	9327-175
C12	Film, .047 MFD, 100V	9327-176
C13	Film, .0047 MFD, 100V	9327-177
C14	Mylar, 470 pf, 250V	9327-178
C15	Ceramic, 200 pf, 1000V	9327-179
C17	Mica, 91 pf, 50V	9327-181
C18	Mylar, 470 pf, 250V	9327-178
C19	Film, .047 MFD, 100V	9327-176
C20A,B,C,	**Electrolytic, 47 MF, 250V, 3 Section**	**9327-071**
C101	**Trimmer, 1.7-10 pf**	**9327-209**
C102	**Trimmer, 2.3-20 pf**	**9180-051**
C103	Mica, 47 pf, 100V	9327-211
C104	**Trimmer, 1.7-10 pf**	**9327-209**
C105	**Trimmer, 2.3-20pf**	**9180-051**
C106	Mica, 430 pf, 300V	9327-214
C107	**Trimmer, 1.7-10 pf**	**9327-209**
C108	**Trimmer, 2.3-20 pf**	**9180-051**
C109	Mica, 4300 pf, 500V	9327-217
C110	**Trimmer, 2.3-20 pf**	**9180-051**
C111,112	**Trimmer, 1.7-10 pf**	**9327-209**
C113	**Trimmer, 2.3-20 pf**	**9180-051**
C114	Mica, 15 pf, 100V	9327-222
C115,116 117,118 119,120	Ceramic, .001 MFD, 1000V	9327-119
C121,122 123,124,125	Ceramic, .01 MFD, 25V	9327-116
C126	Mica, 220 pf, 300V	9327-231
C127	Ceramic, .01 MFD, 25V	9327-116
C128	Ceramic, 20 pf, 1000V	9327-142
C129	Mica, 56 pf, 300V	9327-237
C130,131	Electrolytic, 470 MFD, 25V	9327-238
C132,133	Ceramic, .01 MFD, 25V	9327-116
C134,135	Electrolytic, 1000 MFD, 35V	9327-242

Symbol	Description	Stock No.
C137,138	Ceramic, .01 MFD, 25V	9327-116
C301,302	**Paper, 0.1 MFD, 1600V**	**9327-312**
C303	**Ceramic, .01 MFD, 3000V**	**9327-314**
C304	Ceramic, .01 MFD, 25V	9327-116
C305,306	**Ceramic, .01 MFD, 3000V**	**9327-314**
C307A	**Ceramic, 10 pf, 3000V**	**9327-164**
C308	Mica, 820 pf, 300V	9327-319
C312	Ceramic, 510 pf, 1000V	9327-323
C314	Ceramic, .01 MFD, 25V	9327-116
C315	Mylar, 0.12 MFD, 400V	9327-326
C317	Electrolytic, 4.7 MFD, 25V	9327-328
C318	Ceramic, .01 MFD, 25V	9327-116
C319	Mica, 39 pf, 100V	9327-344
C401	Ceramic, .01 MFD, 600V	9327-133
C402	Ceramic, .022 MFD, 25V	9327-148
C403	Ceramic, 30 pf, 1KV	9327-408
C404	**Variable, 10-60 pf,**	**9327-409**
C405	Ceramic, .022 MFD, 25V	9327-148
C406,407	Ceramic, 68 pf, 1000V	9450-208
C501	Ceramic, .005 MFD, 50V	9327-111
C503	Mylar, .27 MFD, 250V	9327-112
C504	Ceramic, .002 MFD, 1000V	9327-113
C505	Ceramic, .1 MFD, 25V	9327-114
C506	Ceramic, .05 MFD, 25V	9327-115
C507	Ceramic, .01 MFD, 25V	9327-116
C508	Ceramic, 220 pf, 1000V	9327-117
C509	Ceramic, 100 pf, 1000V	9327-118
C510	Ceramic, .001 MFD, 1000V	9327-119
C511	Ceramic, 20 pf, 1000V	9327-142
C512	Ceramic, 300 pf, 1000V	9327-121
C513	Ceramic, 100 pf, 1000V	9327-118
C514	Ceramic, 220 pf, 1000V	9327-117
C515	Ceramic, .001 MFD, 1000V	9327-119
C516	Ceramic, .01 MFD, 25V	9327-116
C518	Ceramic, 10 pf, 1000V	9450-212
C519,520	Ceramic, .01 MFD, 25V	9327-116
C521	Mica, 33 pf, 500V	9327-131
C522	Ceramic, .01 MFD, 25V	9327-116
C523	Ceramic, .01 MFD, 1000V	9327-133
C524	Ceramic .01 MFD, 25V	9327-116
C525	Ceramic, 22 pf, 1000V	9415-209
C526	Ceramic, 3.3 pf, 1000V	9327-136
C527	Ceramic, 220 pf, 1000V	9327-117
C528	Ceramic, .01 MFD, 25V	9327-116
C529	Ceramic, .1 MFD, 25V	9327-114
C530	Ceramic, .01 MFD, 25V	9327-116
C531	Ceramic, 10 pf, 1000V	9450-212
C532	Ceramic, 22 pf, 1000V	9415-209
C533	Ceramic, 47 pf, 1000V	9415-105
C534	Ceramic, 56 pf, 1000V	9327-144
C535	Ceramic, .001 MFD, 1000V	9327-119
C536,537	Ceramic, 220 pf, 1000V	9327-117
C538	Ceramic, .022 MFD, 25V	9327-148
C539	Ceramic, 3.3 pf, 1000V	9327-136
C540	Ceramic, .001 MFD, 1000V	9327-119
C541	Ceramic, 10 pf, 1000V	9450-212
C542,543	Ceramic, .01 MFD, 25V	9327-116
C544	Ceramic, 3.3 pf, 1000V	9327-136
C546	Ceramic, .01 MFD, 25V	9327-116
C547	Ceramic, 220 pf, 1000V	9327-117
C548	Ceramic, 330 pf, 1000V	9415-102
C549	Ceramic, 15 pf, 1000V	9327-159
C550,551	Ceramic, .01 MFD, 25V	9327-116

Symbol	Description	Stock No.
C552	Ceramic, .1 MFD, 25V	9327-114
C545	Ceramic, .01 MFD, 1000V	9327-133
	RESISTORS	
R1	Comp., 4.7K, 5%, ¼W	16-054721
R2	**Film, 11.5 ohms, 2% ½W**	**16-581150**
R3	**Film, 4.6 Meg., 1%, ½W**	**16-574600**
R4	**Film, 2.3 Meg., 1%, ½W**	**16-572300**
R5	**Metal Film, 1.15 Meg., 1%, ½W**	**16-571150**
R6	**Metal Film, 460K, 1%, ½W**	**16-564600**
R7	**Metal Film, 230K, 1%, ½W**	**16-562300**
R8	**Metal Film, 1.15 Meg., 1%, ½W**	**16-571150**
R9,10	Part of S514	
R11	Part of S515	
R12	Part of S513	
R13	Variable, 10K, Dual	9327-024
R15	Metal Film, 510 ohms, 5% 5W	9327-077
R16	Comp., 2.4 Meg., 5%, ¼W	16-052451
R17	Metal Film, 619 ohms, 10%, 6½W	9327-079
R101	Comp., 1 Meg., 5%, ½W	16-081051
R102	**Metal Film, 900K, 1%, ¼W**	**16-569000**
R103	**Metal Film, 111K, 1%, ¼W**	**16-561110**
R104	**Metal Film, 990K, 1%, ¼W**	**16-569900**
R105	**Metal Film, 10.1K, 1%, ¼W**	**16-551010**
R106	**Metal Film, 999K, 1%, ¼W**	**16-569990**
R107	**Metal Film, 1K, 1%, ¼W**	**16-541000**
R108	**Metal Film, 500K, 1%, ¼W**	**16-565000**
R109	**Metal Film, 1 Meg., 1%, ¼W**	**16-571000**
R110	**Metal Film, 800K, 1%, ¼W**	**16-568000**
R111	**Metal Film, 250K, 1%, ¼W**	**16-562500**
R112	Comp., 47 ohms, 5%, ¼W	16-054701
R113,114	Comp., 22K, 5%, ¼W	16-052231
R115	**Variable, 20K, 30%, .20W**	**9327-282**
R116	Comp., 8.2K, 5%, ¼W	16-058221
R117	Comp., 3.3K, 5%, ¼W	16-053321
R118	Comp., 100K, 5%, ¼W	16-051041
R119,120	Comp., 100 ohms, 5%, ¼W	16-051011
R121,122	**Metal Film, 270 ohms, 1%, ¼W**	**16-532700**
R123	Comp., 1 Meg., 5%, ¼W	16-051051
R124	Comp., 100K, 5%, ¼W	16-051041
R125	Comp., 7.5K, 5%, ¼W	16-057521
R126	Comp. 22K 5% ¼W	16-052231
R127	Comp., 300 ohms, 5%, ¼W	16-053011
R128	Comp., 510 ohms, 5%, ¼W	16-055111
R129	Comp., 1K, 5%, ¼W	16-051021
R130	Comp., 510 ohms, 5%, ¼W	16-055111
R131	Comp., 2.7K, 5%, ¼W	16-052721
R132	Comp., 3.3K, 5%, ¼W	16-053321
R133	Comp., 300 ohms, 5%, ¼W	16-053011
R135,136	Comp., 30K, 5%, ¼W	16-053031
R137	Comp., 10 ohms, 5%, ¼W	16-051001
R138,139	Comp., 3.3K, 5%, ¼W	16-053321
R140	Comp., 10 ohms, 5%, ¼W	16-051001
R141	Comp. 510 5% ¼W	16-055111
R142,143	Comp., 91 ohms, 5%, ¼W	16-059101
R144	Comp. 510 5% ¼W	16-055111
R145	Comp., 15 ohms, 5%, ¼W	16-051501
R147	Comp., 10 ohms, 5%, ¼W	16-051001
R148	Comp., 1.8K, 5%, ½W	16-081821
R149	Comp., 36K, 5%, ¼W	16-053631
R150	Comp., 750 ohms, 5%, ½W	16-087511
R151	Comp., 1.8K, 5%, ½W	16-081821
R152	Comp., 100 ohms, 5%, ¼W	16-051011
R153	Comp., 75 ohms, 5%, ¼W	16-057501
R154	Comp., 3.3K, 5%, ¼W	16-053321
R155	Comp., 2K, 5%, ¼W	16-052021
R156	Comp., 11K, 5%, ¼W	16-051131
R157	Comp., 4.7K, 5%, ¼W	16-054721
R158	Comp., 10K, 5%, ¼W	16-051031
R159	**Variable, 10K, 30%, .20W**	**9327-147**
R160	Comp., 47 ohms, 5%, ¼W	16-054701
R161	**Variable, 250 ohms, 30%, .2W**	**9327-218**
R162	**Variable, 50 ohms, 30%, ½W**	**9327-219**
R163	**Variable, 100K, 30%, ¼W**	**9327-221**
R165	Comp., 47 ohms, 5%, ¼W	16-054701
R166	Comp., 1.2 ohms, 5%, ½W	16-080121
R167	Comp., 47 ohms, 5%, ¼W	16-054701
R168	Comp., 1.2 ohms, 5%, ½W	16-080121
R169	Part of S104	
R301	Comp., 51K, 5%, ½W	16-085131
R302	Comp., 24K, 5%, ½W	16-082431
R303	Comp., 6.8 Meg, 5%, ½W	16-086851
R304	Comp., 2.2K, 5%, ¼W	16-052221
R305	Comp., 6.8 Meg, 5%, ½W	16-086851
R306	Comp., 3.9K, 5%, ¼W	16-053921
R307	Comp., 6.8 Meg., 5%, ½W	16-086851
R308	Comp., 33K, 5%, ¼W	16-053331
R309	Comp., 100K, 5%, ¼W	16-051041
R310	Comp., 1.8K, 5%, ¼W	16-051821
R311	Comp., 10K, 5%, ¼W	16-051031
R312	Comp., 56K 5%, ½W	16-085631
R313	Comp., 24K, 5%, ½W	16-082431
R314	**Variable, 20K, ¼W**	**9327-358**
R315	Comp., 22K, 5%, ½W	16-082231
R316	**Variable, 5K,**	**9200-051**
R317	Comp., 560K, 5%, ½W	16-085641
R318	Comp., 51K, 5%, ½W	16-085131
R319	**Metal Film, 500K, 1%, ½W**	**9327-363**
R320	**Metal Film, 280K, 1%, ½W**	**9327-364**
R321	**Variable, 5 Meg.**	**9200-052**
R322	**Metal Film, 976K, 1%, ¾W**	**9327-366**
R323,324	**Metal Film, 732K, 1%, ¾W**	**9327-367**
R325	Comp., 3.9 Meg., 5%, 1W	16-113950
R326	**Comp., 6.2 Meg., 5%, 2W**	**16-146250**
R327	Comp., 22K, 5%, ½W	16-082231
R328	Comp., 6.8K, 5%, ½W	16-086821
R329	**Variable, 100K, ¼W**	**9327-373**
R330	Comp., 6.8K, 5%, ½W	16-086821
R331	Comp., 150K, 5%, ¼W	16-051541
R332	Comp., 43K, 5%, ¼W	16-054331
R333	**Variable, 50K**	**9327-377**
R334	Comp., 10K, 5%, ¼W	16-051031
R335	Comp., 22K, 5%, ¼W	16-052231
R336	Comp., 33K, 5%, ¼W	16-053331
R337	Comp., 51K, 5%, ½W	16-085131
R338	Comp. 10K 5% 2W	16-141030
R339	**Variable 10K 20%**	**9327-147**
R340	Comp. 6.8K 5% ¼W	16-056821
R341	Comp., 3.9K, 5%, ¼W	16-053921
R342	Comp., 33K, 5%, ¼W	16-053331
R344	Comp., 150K, 5%, ¼W	16-051541
R345,346	Comp., 100K, 5%, ¼W	16-051041
R347	Comp., 750K, 5%, ¼W	16-057541
R348	Comp., 300K, 5%, ¼W	16-053041
R349	**Metal Film 3.01K 1% ¼W**	**16-432470**
R350	**Metal Film 14K 1% ¼W**	**16-433150**

Symbol	Description	Stock No.
R351	**Metal Film, 464 ohms, 1%, ¼W**	**16-534640**
R353	**Comp., 6.2 Meg., 5%, 2W**	**16-146250**
R354	Comp., 100 ohms, 5%, ¼W	16-051011
R355	Comp., 27K, 5%, ¼W	16-052731
R356	Comp., 4.7K, 5%, ¼W	16-054721
R357,358	Comp., 510 ohms, 5%, ¼W	16-055111
R401,402	**Metal Film, 2K, 5%, 7W**	**9327-413**
R403,404	Comp., 10 ohms, 5%, ¼W	16-051001
R405,406	Comp., 220 ohms, 5%, 1W	16-112210
R407	Comp., 100 ohms, 5%, ½W	16-081011
R408	Comp., 47 ohms, 5%, ½W	16-084701
R409,410	Comp., 10 ohms, 5%, ¼W	16-051001
R411	Comp., 51 ohms, 5%, ¼W	16-055101
R412	**Variable, 10K**	**9327-424**
R413,414	Comp., 150 ohms, 5%, ¼W	16-051511
R415	Comp., 47 ohms, 5%, ¼W	16-054701
R501,502	Comp., 3K, 5%, ¼W	16-053021
R503	Comp., 2 Meg., 5%, ¼W	16-052051
R504	Comp., 1K, 5%, ¼W	16-051021
R505	Comp., 1 Meg., 5%, ¼W	16-051051
R506	Comp., 15K, 5%, ¼W	16-051531
R507	Comp., 22K, 5%, ¼W	16-052231
R508	Comp., 13K, 5%, ¼W	16-051331
R509	Comp., 3.3K, 5%, ¼W	16-053321
R510	Comp., 4.7K, 5%, ¼W	16-054721
R511	Comp., 10 Meg., 5%, ¼W	16-051061
R512	Comp., 270K, 5%, ¼W	16-052741
R513	Comp., 68K, 5%, ¼W	16-056831
R514	Comp., 1.8K, 5%, ¼W	16-051821
R515	Comp., 3K, 5%, ¼W	16-053021
R516	Comp., 1.5K, 5%, ¼W	16-051521
R517	Comp., 100 ohms, 5%, ¼W	16-051011
R518	Comp., 22K, 5%, ¼W	16-052231
R519	Comp., 1 Meg., 5%, ¼W	16-051051
R520	Comp., 22K, 5%, ¼W	16-052231
R521	Comp., 150K, 5%, ¼W	16-051541
R522	Comp., 110K, 5%, ¼W	16-051141
R523,524 525,526,527	Comp., 100K, 5%, ¼W	16-051041
R528,529, 530	Comp., 1 Meg., 5%, ¼W	16-051051
R531	Comp., 22K, 5%, ¼W	16-052231
R532,533	Comp., 120K, 5%, ¼W	16-051241
R534	Comp., 3K, 5%, ¼W	16-053021
R535	Comp., 510 ohms, 5%, ¼W	16-055111
R536	Comp., 270 ohms, 5%, ¼W	16-052711
R537,538	Comp., 390 ohms, 5%, ¼W	16-053911
R539	Comp., 47 ohms, 5%, ¼W	16-054701
R540	Comp., 820K, 5%, ¼W	16-058241
R541	Comp., 430K, 5%, ¼W	16-054341
R542	Comp., 1.2 Meg., 5%, ¼W	16-051251
R543	Comp., 300K, 5%, ¼W	16-053041
R544	Comp., 300 ohms, 5%, ¼W	16-053011
R545	Comp., 3K, 5%, ¼W	16-053021
R546	Comp., 1.2K, 5%, ¼W	16-051221
R547	Comp., 100K, 5%, ¼W	16-051041
R548	Comp., 47K, 5%, ¼W	16-054731
R549	Comp., 12K, 5%, ¼W	16-051231
R550	Comp., 100K, 5%, ¼W	16-051041
R551	Comp., 10 ohms, 5%, ¼W	16-051001
R552	Comp., 1 Meg., 5%, ¼W	16-051051
R553	Comp., 1.3 Meg. 5%, ¼W	16-051351
R554	Comp., 100 ohms, 5%, ¼W	16-051011
R555	Comp., 9.1 Meg., 5%, ¼W	16-059151
R556	Comp., 430K, 5%, ¼W	16-054341
R557	Comp., 6.8K, 5%, ¼W	16-056821
R558	**Variable, 10K, 20%**	**9327-147**
R559	Comp., 1.6K, 5%, ¼W	16-051621
R560	Comp., 3.3K, 5%, ¼W	16-053321
R561	Comp., 3.9K, 5%, ¼W	16-053921
R562	Comp., 12K, 5%, ¼W	16-051231
R563	Comp., 18K, 5%, ¼W	16-051831
R564	Comp., 6.8K, 5%, ¼W	16-056821
R565	Comp., 750 ohms, 5%, ¼W	16-057511
R566	Comp., 47 ohms, 5%, ¼W	16-054701
R567	Comp., 6.8K, 5%, ¼W	16-056821
R568	Comp., 3.9K, 5%, ¼W	16-053921
R569	Comp., 1K, 5%, ¼W	16-051021
R570	Comp., 2K, 5%, ¼W	16-052021
R571	Comp., 1K, 5%, ¼W	16-051021
R572	Comp., 2K, 5%, ¼W	16-052021
R573,574	Comp., 4.7K, 5%, ¼W	16-054721
R575	Comp., 5.6K, 5%, ¼W	16-055621
R576	Comp., 1.2 Meg., 5%, ¼W	16-051251
R577	Comp., 390K, 5%, ¼W	16-053941
R578	Comp., 100 ohms, 5%, ¼W	16-051011
R579	Comp., 1.5K, 54, ¼W	16-051521
R580	Comp., 100 ohms, 5%, ¼W	126-051011
R581	Comp., 1K, 5%, ¼W	16-051021
R582	Comp., 12K, 5%, ¼W	16-051231
R583	Comp., 10K, 5%, ¼W	16-051031
R584	Variable, 10K, 20%	9327-147
R585	Comp., 3.9K, 5%, ¼W	16-053921
R586	Comp., 5.1K, 5%, ¼W	16-055121
R587	Comp., 12K, 5%, ¼W	16-051231
R588	Comp., 3.3K, 5%, ¼W	16-053321
R589	Comp., 22 ohms, 5%, ¼W	16-052201
R590	**Variable, 2K, 20%**	**9327-179**
R591	Comp., 1.3 Meg., 5%, ¼W	16-051351
R592	Comp., 2K, 5%, ¼W	16-052021
R593,594	Comp., 510K, 5%, ¼W	16-055140
R595	Comp., 10K, 5%, ¼W	126-051031
R596	Comp., 680K, 5%, ¼W	16-056841
R597	Comp. 3.9M 5% ¼W	16-053951
R598	Comp., 680 ohms, 5%, ½W	16-086811
R599	**Variable, 5K, 20%**	**9327-151**
R600	Comp., 7.5K, 5%, ¼W	16-057521
R601	Comp., 62K, 5%, ¼W	16-056231
R602	Comp., 100K, 5%, ¼W	16-051041
R603	Comp., 1.8K, 5%, ¼W	16-051821
R604	Comp., 5.1K, 5%, ¼W	16-055121
R605	Comp., 20K, 5%, ¼W	16-052031
R606	Comp., 390 ohms, 5%, ¼W	16-053911
R607	Comp., 1.1 Meg., 5%, ¼W	16-051151
R608	Variable 5K 20%	9327-151
R609	Comp., 2.7K, 5%, ¼W	16-052721
R610	Comp., 11K, 5%, ¼W	16-051131
R611	Comp., 1.3K, 5%, ¼W	16-051321
R612	Comp., 10K, 5%, ¼W	16-051031
R613	Comp., 100K, 5%, ¼W	16-051041
R616	Comp., 100K, 5%, ¼W	16-051041
R617,618	Comp., 820 ohms, 5%, ¼W	16-058211

Symbol	Description	Stock No.
R620	Comp., 5.1K, 5%, ¼W	16-055121
R621	**Variable, 100 ohms, 20%**	**9327-152**
R623	Comp., 2.4K, 5%, ¼W	16-052421
R624	Comp., 200 ohms, 5%, ¼W	16-052011
R625	Comp., 560 ohms, 5%, ¼W	16-055611
R626,627	Comp., 750 ohms, 5%, ¼W	16-057511
R628	Comp., 1.3K, 5%, ¼W	16-051321
R629	Comp., 300 ohms, 5%, ¼W	16-053011
R630	Comp., 7.5K, 5%, ¼W	16-057521
R631	Comp., 270K, 5%, ¼W	16-052741
R632	Comp., 22K, 5%, ¼W	16-052231
R633	Comp., 22 ohms, 5%, ¼W	16-052201
R635	Comp., 22K, 5%, ¼W	16-052231
	Transistor	
Q101,102	Type-FET (matched pair)	9327-075
Q103	Type-2N6000	12-060001
Q104	Type-2N6109	12-061091
Q105	Type-2N6290	12-062901
Q301,302, 303	Type, NSD 134	21-900006
Q304	Type-2N5821	12-058211
Q305, 307	Type 2N2102	12-021021
Q308	Type-2N6000	12-060001
Q401,402	Type-NSD 128	12-900001
Q403,404	Type-2N6000	12-060001
Q501,502, 503	**Type-RCA 40841**	**12-408411**
Q504	Type-2N6000	12-060001
Q505,506	**Type-RCA 40841**	**12-408411**
Q507,508	NSD 129	12-900002
	Diodes	
CR1,2	**Type-LED, OPL-209A Red**	**9327-073**
CR3	**Type-LED, OPL-211 Green**	**9327-074**
CR4	**Type-LED, OPL-209A Red**	**9327-073**
CR5,6,7,8	Type-RCA1201D	11-900001
CR101,102	Type-1N4148	11-041481
CR103	Varo W02M Bridge Rectifier	9327-252
CR301,302	**Type-VG3**	**11-900000**
CR303	Type-RCA D1201D	11-900001
CR304	Type-RCA D1201M	11-900002
CR305	Type-RCA D1201P	11-900003
CR307	Type-1N3255	11-325501
CR308	**Type-1N5267, Zener**	**11-526701**
CR309-313	Type1N4148	11-041481
CR501 to 506	Type-1N4148	11-041481
CR507	Type-A25835	11-900004
CR508-528	Type-1N4148	11-041481
	Switches	
S101,102, S103	Switch Pushbutton-DC, Gnd., AC	9327-206
S104	Switch, Rotary-Vert/Volts, Div.	9327-220
S301	Switch, On-Off	9327-396
S501-511	Switch, Pushbutton-Horizontal Functions	9327-106
S512	Switch, Pushbutton	9327-108
S513	Switch-Trig. Pushbutton Pot.	9327-90
S514	Switch, Rotary Sweep Time/Div.	9327-110
	Integrated Circuits	
U101,102	**Type-RCA CA3083**	**14-030835**
U103	**Type-Motorola MC14681**	**14-014685**
U301	**Type-RCA CA3084**	**14-030845**
U302	**Type-RCA CA3094E**	**14-030945**
U501,502, 503	**Type-RCA CA3086**	**14-030865**
U504	**Type-RCA CA1458E**	**14-014585**
U505	**Type-RCA CA3100S**	**14-031005**
U506	**Type-RCA CA3183**	**14-031835**
	Inductors	
L1,L2	**Coil, Choke**	**9327-025**
	Miscellaneous	
	Cathode-Ray Tube 5-inch #130BRB31	**9327-031**
	Clamp, CRT	**9327-480**
	Connector, BNC	**9327-065**
	Cover, Top	**9327-015**
	Cover, Bottom	**9327-017**
	Bezel, Front-Molded	**9327-002**
	Feet	**9327-052**
	Fuse, Holder	**9327-053**
F1	**Fuse Type 3AG, 1.5A**	**9327-054**
	Graticle	**9327-041**
	Handle	**9327-255**
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	Jack, Phono	**9327-059**
	Jack, Tip-Grey	**9327-058**
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	Knob, Horiz. Magnifier-Top	**9200-142**
	Knob, Horiz. Magnifier-Bottom	**9200-144**
	Knob, Trig.	**9200-146**
	Knob, Vertical Pos.	**9200-148**
	Knob, Power, Intensity, Focus	**9200-151**
	Knob, Time Sweep Division	**9327-460**
	Knob, Vert. Volts Division	**9327-470**
	PCB High Voltage, Loaded w/components	**9327-300**
	PCB Horizontal, Loaded w/components	**9327-280**
	PCB Vert. Amp. Loaded w/components	**9327-230**
	PCB Vert. Power Out, Loaded w/components	**9327-250**
	Power Cord	**9415-026**
K501	**Relay, Reed**	**9327-197**
	Shield, CRT	**9327-055**
	Shield, Top-For S104	**9327-033**
	Shield, Bottom-For S104	**9327-034**
	Socket Assy, CRT	**9327-060**
	Strain Relief	**9415-021**
S1	**Switch, Slide**	**9327-056**
T1	**Transformer, Power**	**9327-037**
WG-478	**Probe Complete (V1 thru V7)**	**9892**
WG-478-V1	**Compensator**	**9892-040**
WG-478-V2	**X10 Probe Tip**	**9892-020**
WG-478-V3	**Direct Probe Tip**	**9892-030**
WG-478-V4	**Hook on Tip for Scope Probe**	**9892-010**
WG-478-V5	**I.C. Tip**	**9892-013**
WG-478-V6	**Isolation Tip**	**9892-016**
WG-478-V7	**Ground Clip Assy**	**9892-050**

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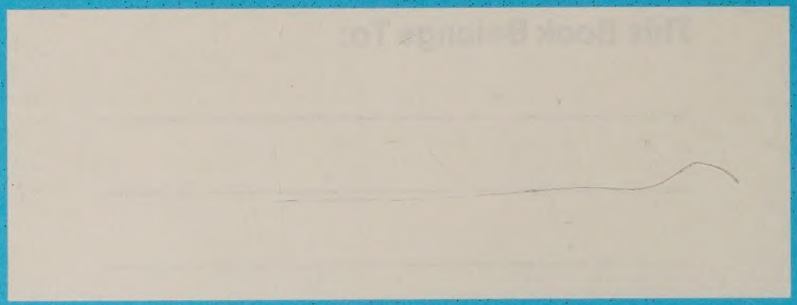

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